

KUNGL. SVENSKA VETENSKAPSAKADEMIENS HANDLINGAR
TREDJE SERIEN. BAND 6. N:o 6.

THE SPACE DISTRIBUTION OF B AND A TYPE STARS IN BRIGHT AND DARK GALACTIC REGIONS

RESEARCHES BASED ON DETERMINATIONS OF SPECTRAL
TYPE AND LUMINOSITY CLASS FOR 4300 STARS

ACADEMICAL DISSERTATION

BY

CARL SCHALÉN

UPPSALA 1928

ALMQVIST & WIKSELLS BOKTRYCKERI-A.-B.

4°
Uppsala
1928

THE SPACE DISTRIBUTION OF B AND A TYPE STARS IN BRIGHT AND DARK GALACTIC REGIONS

RESEARCHES BASED ON DETERMINATIONS OF SPECTRAL
TYPE AND LUMINOSITY CLASS FOR 4300 STARS

ACADEMICAL DISSERTATION

BY

CARL SCHALÉN

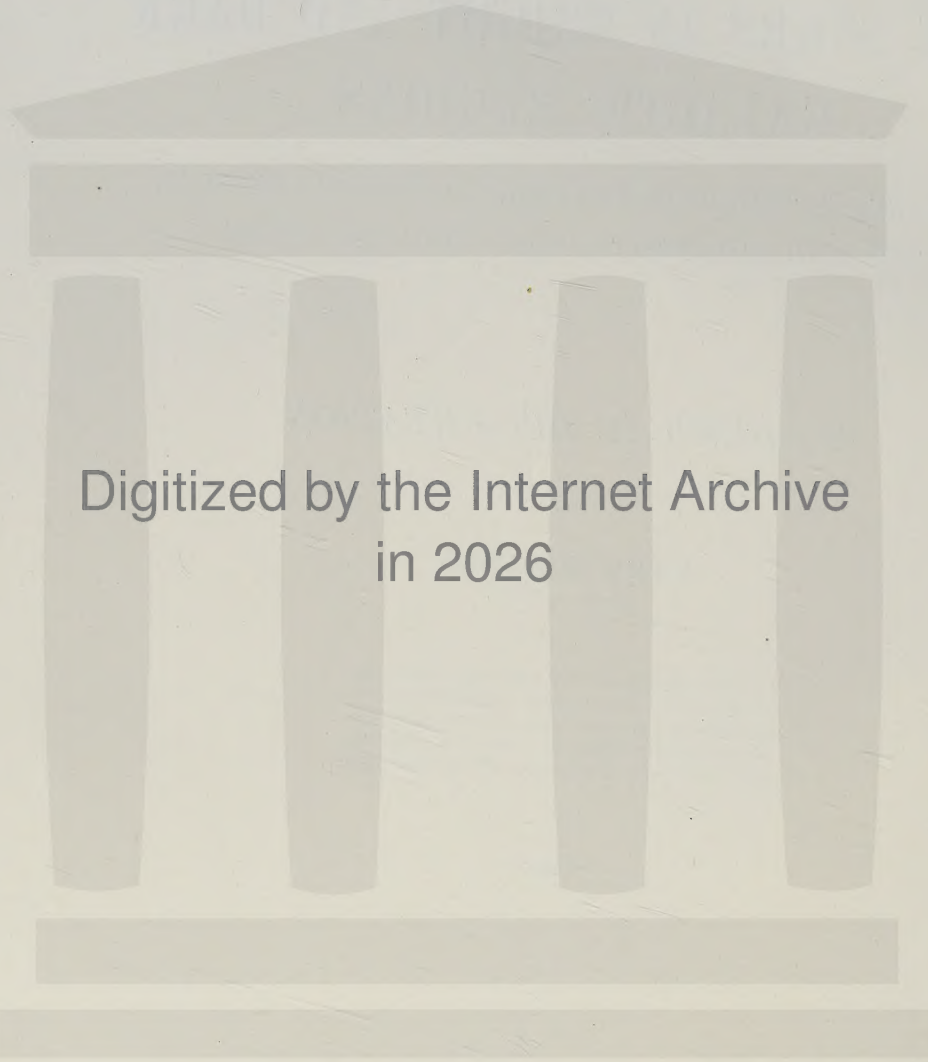
FIL. LIC., STOCKH.

BY DUE PERMISSION OF THE PHILOSOPHICAL
FACULTY OF UPSALA TO BE PUBLICLY DISCUS-
SED IN THE LECTURE HALL OF THE PHYSICAL
INSTITUTION DECEMBER 1 1928 AT 10 A. M. FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

UPPSALA 1928

ALMQVIST & WIKSELLS BOKTRYCKERI-A.-B.

*1/633



Digitized by the Internet Archive
in 2026

https://archive.org/details/IA41551518_0004

KUNGL. SVENSKA VETENSKAPSAKADEMIENS HANDLINGAR

TREDJE SERIEN. BAND 6. N:o 6.

THE SPACE DISTRIBUTION OF B AND A TYPE STARS IN BRIGHT AND DARK GALACTIC REGIONS

RESEARCHES BASED ON DETERMINATIONS OF SPECTRAL
TYPE AND LUMINOSITY CLASS FOR 4300 STARS

BY

CARL SCHALÉN

WITH 21 FIGURES IN THE TEXT

COMMUNICATED SEPTEMBER 12th 1928 BY H. VON ZEIPPEL AND Ö. BERGSTRAND

STOCKHOLM

ALMQVIST & WIKSELLS BOKTRYCKERI-A.-B.

1928

THE SPACE DISTRIBUTION OF B AND A
TYPE STARS IN BRIGHT AND DARK
GALACTIC REGIONS

THE SPACE DISTRIBUTION OF B AND A
TYPE STARS IN BRIGHT AND DARK
GALACTIC REGIONS

RESEARCHES IN THE HISTORY OF ASTRONOMY
AND COSMOLOGY

ASTRONOMY



LEIDEN

LEIDEN

STOCKHOLM

STOCKHOLM

1928

Preface.

The paper here presented contains an account of investigations which have been carried out at the Upsala Observatory during the last three years.

The greatest part of the treatise is devoted to a study of the space distribution of the *B* and *A* stars in four galactic regions, including bright, as well as dark parts of the Milky Way. From a comparison of the density curves in adjacent areas of different galactic structure conclusions have been drawn regarding the distance and absorption of the dark nebulae which, with the greatest probability, are the cause of the dark tracts of the Milky Way. Besides this, among other matters, the concentration of the white stars to the galactic plane has been studied, as well as the lines of equal density in this plane, together with the luminosity curve of the *A* stars.

The material obtained by observation consists of short objective prism spectra for stars down to photographic magnitude 10.5—11.0. The statistical treatment of the material is based upon the absolute magnitudes previously determined at Upsala.

On this occasion it is my pleasant duty to express my warmest gratitude to Professor ÖSTEN BERGSTRAND, Director of the Upsala Observatory, for the ready courtesy he has always shown during my investigations, and for the interest he has displayed in the present work.

The investigation was begun at the suggestion of Professor BERTIL LINDBLAD, now Director of the Observatory at Stockholm. He has shown the greatest interest in the development of my researches and has given me much valuable advice and criticism during the course of my work. For this, as well as for all the kindness he has shown me during my studies in Upsala, I wish to offer him my sincere and heartfelt thanks.

Professor HUGO VON ZEIPPEL and Dr. KNUT LUNDMARK have also, on several occasions, exhibited their interest in my investigations, for which I beg to express my sincere thanks.

Finally I am indebted to Dr. HARALD PETERSSON and Mr. YNGVE ÖHMAN for their helpfulness in various respects.

Upsala, August 1928.

Carl Schalén.

CHAPTER I.

Short Survey of the Problem of Determining the Space Distribution of the Stars. Outline of the Present Investigation.

1. For a complete solution of the problem of determining the space distribution of the stars it would be necessary to determine the distance of every star. The possibility of the direct determination of stellar distances by trigonometric methods is, however, limited to our nearest surroundings of space, a fact perceived already by Sir WILLIAM HERSCHEL. Therefore our problem must be treated statistically and solved on the basis of the observed surface distribution of the stars of different apparent magnitudes. The problem may be attacked in successive approximations.

The *first approximation* for the study of the distribution of the stars is to assume that the system has spherical symmetry around our situation in space: the density function is the same in all directions. The influence of the concentration of the stars to the plane of the Milky Way is thus neglected. This simplification of the problem gives rise to the so-called *schematic universe* that, certainly, has not much in common with the true stellar system.

In the *second approximation* the space distribution is studied taking into consideration the influence of the galactic latitude which is very marked in the apparent distribution. The sky is divided into zones parallel to the galactic plane; within each zone the same density law is assumed as being valid everywhere, and no regard is paid to the variation of the distribution with galactic longitude. The system derived in this manner is called the *typical universe*. Of course the stellar distribution within the typical universe must also deviate considerably from the actual one, as the variation of the distribution in galactic longitude is very pronounced, especially within the Milky Way zone.

The *third approximation* bearing upon a representation of the *true stellar system* must therefore make allowance for the influence on the distribution of the stars of both the galactic latitude and longitude. The sphere must be divided into such small areas that the combination of the stars within each area does not imply any risk that the results will be smoothed and deviate from reality. Especially as to the galactic zone we are in this approximation concerned with detailed studies, where the limits of the areas have to be chosen according to the appearance of the galactic structure.

Finally, as a special case we have to study the distribution in space of stars of different spectral types. By the help of the modern spectroscopic methods, for determining the absolute magnitudes of stars, it has been made possible to get an idea of the distances of stars that lie far beyond the limits reached by the direct parallax measurements. At first it seems, therefore,

that these methods would make it possible to study the space distribution directly from the calculated distance of each individual star. But the absolute magnitudes determined spectroscopically are, generally, mean magnitudes for classes of stars, the absolute magnitudes of the individual members of this class being distributed around the mean according to a certain law. If this law is known we can study, *statistically*, the space distribution of stars of different spectral types, a problem of great importance.

2. The relation between the frequency function of the apparent magnitudes, $b(m)$, the frequency function of the absolute magnitudes, $\varphi(M)$, and the density function, $D(r)$, is expressed by the equation

$$b(m) = \omega \int_0^{\infty} D(r) \varphi(M) r^2 dr,$$

the fundamental equation of stellar statistics in its most simple form. ω is the solid angle corresponding to the area of the sky in question. $D(r)$ is thus dependent on the other two functions. The determination of $b(m)$ through counts of stars of different m requires an accurate knowledge of the apparent magnitudes of the stars. Notwithstanding the difficulties of obtaining $b(m)$ down to faint magnitudes I think it may be said that the greatest difficulty for the determination of the function $D(r)$ has been the incomplete knowledge of the function $\varphi(M)$. Through determinations of mean parallaxes of groups of stars KAPTEYN¹ was able, however, to deduce this function for stars of all spectral types taken together. It was found to have the form of a normal error curve², a result often used in statistical researches.

When stars of a certain spectral type or sub-group of a spectral type are considered the absolute magnitudes are also assumed to be distributed around their mean according to a normal error curve.

$\varphi(M)$ is considered independent of the coordinates. When all stars are treated without regard to spectral type this is certainly not true — the dependence on spectral type of the distribution of the stars being well-known. But for stars of a certain spectral group for which the dispersion of the magnitudes is small, this assumption is justified.

In researches on the distribution of the stars the absorption of light is neglected. Except for certain regions that have to be treated specially this assumption seems to be perfectly justified from known observational facts (cf. also ch. V).

¹ KAPTEYN, On the mean parallax of stars of determined proper motion and magnitude, Gron. Publ., No. 8 (1901).

² KAPTEYN and V. RHLJN, On the distribution of the stars in space especially in the high galactic latitudes, Mount Wilson Contr., No. 188; Astrophys. Journal, 52 (1920), On the arrangement of stars in space, Mount Wilson Contr., No. 229, Astrophys. Journal, 55 (1922).

3. It is not my intention to give a complete review of the problem of determining the space distribution of the stars. This would carry us too far. I will here only refer to some important researches that have, successively, contributed to increase our knowledge of the arrangement of stars in space.

SIR WILLIAM HERSCHEL was the first to study the distribution of the stars on the basis of extensive observations. The results of his star gauges are published in a series of papers »On the Construction of the Heavens».¹ In his earlier works HERSCHEL aimed at forming an idea of how far his instrument could reach in different directions, and for this purpose he started from the following assumptions concerning the density function and the absolute magnitudes, namely

$$D(r) = \text{const.}, \quad M = \text{const.}$$

Thus these researches do not give any idea of the mutual distribution of the stars as this is presumed to be uniform. But this hypothesis permitted HERSCHEL to compute the relative distances of the stars in various directions from the number of stars counted. In this manner he got a rough idea as to the relative extension of the stellar system in different directions. — In his later researches HERSCHEL gave up the hypothesis of uniform distribution, assuming instead a certain law for the computation of the number of stars in spherical shells around the sun. He assumed that in the mean the apparent magnitudes of the stars should be a measure of their relative distances.

This hypothesis of the apparent magnitudes as a measure of the relative distances in the mean (that is nearly constant M) was also the basis for the researches of W. STRUVE on the distribution of the stars.² SCHIAPARELLI³ pointed out that this hypothesis and the more general one

$$D(r) = \text{const.}, \quad \varphi(M) = \text{arbitrary},$$

lead to the same ratio

$$B(m) : B(m-1) = 3.981$$

between the total number of stars brighter than m and the total number brighter than $m-1$. This is not in agreement with the observations.

¹ W. HERSCHEL, Account of some observations tending to investigate the construction of the Heavens, Phil. Trans. 1784; On the construction of the Heavens, Phil. Trans. 1785; Astronomical observations relating to the construction of the Heavens, Phil. Trans. 1811; Astronomical observations and experiments tending to investigate the local arrangement of the celestial bodies in space, and to determine the extent and condition of the Milky Way, Phil. Trans. 1817. (These researches are to be found in »The scientific papers of Sir William Herschel», vol. I, pp. 157 and 223, and II, pp. 459 and 575.)

² W. STRUVE, Études d'Astronomie stellaire, St. Pétersbourg 1847.

³ SCHIAPARELLI, Sulla distribuzione apparente delle stelle visibili ad occhio nudo, Pubb. del R. Oss. di Brera in Milano, 34 (1889).

The investigations of SEELIGER¹ begun in the eighties, were of great importance. SEELIGER deduced the formulae connecting the unknown functions $D(r)$ and $\varphi(M)$ — later on SEELIGER introduced a third unknown function: the absorption of light in space — with those given by observation, namely the frequency function of the apparent magnitudes and the mean parallax function. This was made under the general assumption that the stellar system has a finite extension and that the intrinsic luminosities of the stars cannot reach too high values. From his investigations SEELIGER was led to the density function

$$D(r) = \mu r^{-s}.$$

SEELIGER's first investigations refer to the schematical universe, the constants of the density function being independent of the coordinates, his later researches to the typical universe, μ and s being functions of the galactic latitude. From his formulae SEELIGER could also derive the luminosity function using KAPTEYN's mean parallaxes as a check.

KAPTEYN's fundamental researches on the arrangement of stars in space were based on investigations of the mean parallaxes of stars.^{2, 3} Besides the mean parallax for groups of stars KAPTEYN also derived the distribution function of the parallaxes around their mean. Having determined, for groups of stars of a given apparent magnitude, the number of stars of different mean parallax, the absolute magnitude is also known for these stars. Consequently, KAPTEYN was able to deduce both the luminosity function and the density function *without any presumption as to the analytical form of the latter function*. This is an important point which will be referred to later on. For distances greater than about 1000 parsecs the mean parallaxes were, however, uncertain and KAPTEYN, therefore, could not derive the densities in this manner. He now used another method. It was found that the apparent magnitude curve could, approximately, be represented by an exponential function:

$$b(m) = e^{a+bm+cm^2}. \quad (1)$$

As was mentioned above he had found a similar expression for $\varphi(M)$:

$$\varphi(M) = e^{p+qM+rM^2}. \quad (2)$$

The fundamental equation of stellar statistics was solved completely by SCHWARZSCHILD by the use of the integral of FOURIER. From the theoreti-

¹ A summary of the scientific work of Seeliger is given by DEUTSCHLAND, Die Untersuchungen H. v. Seeligers über das Fixsternsystem, Vierteljahrsh. d. astr. Gesellsch. 1919. — Besides: SEELIGER, Untersuchungen über das Sternsystem, Sitz. ber. d. Bay. Ak. der Wissenschaften, 1920.

² KAPTEYN, Loc. cit., also Gron: publ., No. 11 (1902) and No. 29 (1918).

³ KAPTEYN and V. RHIJN, Loc. cit.

cal researches of SCHWARZSCHILD¹ it follows that, when $b(m)$ and $\varphi(M)$ have the forms given here, $D(r)$ must have the form

$$D(r) = e^{h+k(\log r)+l(\log r)^2}, \quad (3)$$

where the coefficients h , k , and l are connected with those of $b(m)$ and $\varphi(M)$ by simple relations. For zones parallel with the galactic plane KAPTEYN computed the coefficients of this density function (the typical universe). The density distribution within the KAPTEYN universe for distances >1000 parsecs is thus, in reality, based on a presumption as to $D(r)$ even if its form was derived from empirical results concerning $b(m)$ and $\varphi(M)$. For distances <1000 parsecs this method was used too, and gave results in agreement with those derived from the mean parallaxes.

All the researches hitherto mentioned concern the schematical or the typical universe. In order to account for the influence of the galactic longitude CHARLIER, in his investigations², divided the sphere into 48 equal »squares». Within each such area he assumed that the density function was invariable. With this procedure, however, no consideration is taken to the special features of the galactic structure.

In an investigation published in 1924³ PANNEKOEK points out the necessity of treating the special galactic formations specially determining the density function for each area separately. On the basis of the Durchmusterung catalogues (after a careful reduction of the magnitudes) PANNEKOEK tries to determine the difference in star-density between the true stellar system and KAPTEYN's typical universe performing his computations for a great number of areas. PANNEKOEK uses the luminosity curve found by KAPTEYN and represents the star-numbers by an exponential function. Consequently his density function has the form (3), where, of course, the coefficients vary with both galactic latitude and longitude. They are computed for different areas from which the difference in space density between the »true» system and the typical one is obtained. PANNEKOEK also devotes special interest to certain *regions of great or low star-density*.

PANNEKOEK's work is, I think, the first that really tries to take the special galactic features into consideration. The irregularities of the surface distribution were certainly studied already about 1900 by STRATONOFF⁴, with special attention to the galactic structure. His star-counts were based on the uncorrected Durchmusterung magnitudes, which must reduce the reliability of

¹ SCHWARZSCHILD, Über die Integralgleichungen der Stellarstatistik, Astr. Nachr., No. 4422, (1910).

² CHARLIER, Studies in stellar statistics, I, Constitution of the Milky Way, Medd. fr. Lunds astr. observ., II, 8 (1912).

³ PANNEKOEK, Researches on the structure of the universe, I. The local star system deduced from the Durchmusterung Catalogues, Publ. of the Astronomical institute of the University of Amsterdam, No. 1 (1924).

⁴ STRATONOFF, Études sur la structure de l'univers, Publ. de l'observatoire de Tachkent, 2, 3 (1900, 1901).

his results. The space distribution was not studied. STRATONOFF also studied the surface distribution of stars of different spectral types on the basis of the spectra of Harvard Annals, No. 28.

Since the completion of the Henry Draper Catalogue it has become possible to make detailed researches as to the distribution of stars of different spectral types. I will here only call to mind the well-known researches of CHARLIER concerning the space distribution of the bright *B* stars.¹ His work last-cited is based on all stars in the Draper Catalogue brighter than the 8th magnitude. According to CHARLIER the *B* stars should form a limited system surrounding our sun, where the density distribution is characterized by a flattened spheroid with its shortest axis in the direction of the pole of the Milky Way.

Now the difficulty arises that the spectra are, generally, not known for faint stars. Another difficulty is that giants and dwarfs are generally not separated. At the classification of spectra for the study of the distribution in space of the stars it is, therefore, necessary to use methods permitting us to *distinguish between stars of different intrinsic luminosity within a given spectral class* by means of such effects in stellar spectra that are intimately related to the absolute magnitude.

Through the investigations at the Upsala Observatory during recent years spectra and absolute magnitudes have been determined for a great number of stars, in different regions of the sky, by the use of spectrophotometric methods introduced by Professor LINDBLAD. Thus the distribution in space of the stars of different spectral types can be studied for these limited regions. Such investigations have been made by LINDBLAD² for a part of the Greenwich zone, between $8^{\frac{1}{2}}$ and $14^{\frac{1}{2}}$, and by PETERSSON³ for the Carrington north polar zone. A study of the space distribution of the different spectral types has also been performed recently, by MAXWELL⁴, for some »selected areas» in the Cygnus region of the Milky Way.

In such researches the greatest interest is attached to the white stars and the late type giants as they have high intrinsic luminosity. Thus great distances can be reached even if the research does not embrace very faint stars.

4. The *B* and *A* type stars, and particularly the absolutely brightest stars show a strong concentration towards the galactic plane. Their absolute magnitudes are well known through researches performed at Upsala by the use

¹ CHARLIER, Studies in stellar statistics, III, The distances and the distribution of the stars of the spectral type B, Nova Acta Reg. Soc. Scient. Upsaliensis, Ser. IV, 4, No. 7.¹ Medd. fr. Lunds astr. observ., II, 14 (1916). Studies in stellar statistics, V. On the galaxy of the *B* stars, Ibid., vol. extra ordinem ed. 1927, ibid. II, 34 (1926).

² LINDBLAD, On the decrease of star-density with distance from the galactic plane, Arkiv för matem., astr., & fys., 19 B, 15. Medd. fr. Astr. observ. Upsala, No. 14 (1926).

³ PETERSSON, The distribution of distances and velocities of stars in the Carrington zone on the basis of spectrophotometric analysis, Medd. fr. Astr. observ. Upsala, No. 29 (1927).

⁴ MAXWELL, The space distribution of the stars of different spectral classes as determined from studies in the Cygnus region of the Milky Way, Lick Obs. Bull., No. 390 (1927).

of the special luminosity classes. A study of the space distribution of the white stars in regions situated in or near the Milky Way, may therefore be of a certain interest. It is on account of reflections of this kind that the present research has been undertaken. It deals mainly with the space density of the *B* and *A* type stars in four galactic regions situated in Cygnus, Cepheus, Cassiopeia, and Auriga. After what has been said in the foregoing pages I need hardly emphasize the importance of combining the observations to the averages for small areas only showing uniform galactic structure. A material part of this paper bears upon a comparison between the space density in regions of different galactic structure in order to investigate the eventual existence of absorbing dark nebulae.

In *Chapter II* a survey is given of the material upon which the present research is based and of the spectral classification of the white stars according to the Upsala and Harvard systems. The total number of *B* and *A* stars amounts to 4300 down to photographic magnitude 10.5—11.0.

Chapter III deals with the determination of the apparent photographic magnitudes directly from the series of spectral images for each star on the plate, and the reduction of the magnitudes. Finally, a short summary of the Upsala determinations of absolute magnitudes for *B* and *A* stars is given.

The derivation of the star-densities treated in *Chapter IV* is founded upon a method proposed by LINDBLAD and analogous to that used by KAPTEYN. No presumption as to the form of the density function is made. Within each luminosity group the absolute magnitudes are assumed to be distributed according to a normal error curve with known mean value and dispersion. Then the mean absolute magnitude and dispersion for stars of a certain apparent magnitude are calculated according to MALMQUIST's relations after which the stars of each group are distributed in a distance-magnitude table. Then the number of stars within intervals of distance is obtained and thus also the densities.

In *Chapter V* the existence of dark nebulae is discussed and the influence of such nebulae on the true space distribution of the stars. The method given by PANNEKOEK for the determination of the distance, and absorbing power, of a dark nebula is treated.

In *Chapter VI* the results of the computation of the densities are given for each of the four regions separately. Both the area densities and the space densities for the stars of different luminosity groups are discussed. Stress is laid upon the comparison of results from bright and dark regions. Distances of dark nebulae are derived.

Chapter VII deals mainly with a comparison of the results from the different regions. Equi-density lines are drawn. The densities here calculated are compared with those found in regions at high galactic latitudes. The luminosity curve of the *A* stars is discussed.

A general catalogue of the stars used for the present investigation is given.

CHAPTER II.

The Material. Spectral Classification of the Stars.

1. In four galactic regions spectra have been determined for a great number of stars down to the photographic magnitude 10.5—11.0. All the plates were made with the Zeiss-Heyde astrograph of the Upsala Observatory. The focal length of this instrument is 150 cm. In front of one of the two 15 cm triplet cameras of the instrument an objective-prism of $9^{\circ}.7$ refracting angle is mounted. The spectra obtained are very short, the distance on the plate between $H\gamma$, and $H\epsilon$ being only 1.4 mm.

On each plate a series of exposures were made. First the plate was exposed 40 minutes, then the whole plate-holder was displaced at right angles to the longitudinal direction of the spectra by a screw and the second exposure, 20 min., was made, and so on, the shortest exposure being 5 seconds. The total exposure-time for each plate amounts to 1 hour 20 minutes as the exposure ratio between two successive images is always taken $= 2$. This series of narrow spectral images is necessary for several purposes. For the early type stars it is of great importance in estimating the sharpness of the hydrogen lines, the criterion of absolute magnitude for these stars; for the late type stars the absolute luminosities can be determined from density measurements obtained by comparing, in successive images, the density of certain spectral regions. Furthermore, in the present research, this scale of images was used to determine, by means of density measurements, the apparent photographic magnitudes of the *B* and *A* stars.

The plates were exposed only under the best weather conditions and always rather near the meridian. Special attention was devoted to seeing that no fluctuations of brightness of the guiding star should occur during the whole exposure-time, as the sequence of images had to be used for photometric and other density measurements. Several plates owing to this cause were rejected, but the rejected plates could naturally be used for testing the spectral classification from the new plate of the same region. The data of the plates are given on p. 12.

The plates used are Imperial S.S. plates, 16×16 cm. Between the wavelengths of $H\gamma$ and $H\epsilon$ the spectral images can be obtained in good focus over the whole plate, excepting one or two cm at one side. Near this border no measurements were made. The plates were developed about 7 minutes in a hydroquinone developer of about 18° temperature.

2. For the present research four regions in the Milky Way were chosen. The arrangement of the plates in these regions is shown in Fig. 1. In *Cygnus* six plates are exposed forming a band at right angles to the galactic plane across the great Cygnus cloud near γ Cyg. The galactic longitude of this region is about 43° . In *Cepheus* at galactic longitude about 70° (at ϵ and

Pl. No.	Day of exp.	Sid. time at the beginning of exp.	Right asc. of centre	Decl. of centre	Reg.
1	Aug. 19, 1925	20 ^h 7 ^m	20 ^h 20 ^m	35° 40'	Cyg
3	» 23 »	20 26	20 6	37 13	Cyg
4	» 26 »	21 6	19 53	39 0	Cyg
6	Sept. 13 »	20 39	20 42	30 30	Cyg
9	» 16 »	22 39	22 24	54 0	Cep
10	» 18 »	20 16	19 37	41 20	Cyg
11	» 18 »	22 1	22 44	50 50	Cep
12	Oct. 10 »	23 2	21 50	59 30	Cep
13	Nov. 11 »	2 45	1 47	63 11	Cas
14	» 16 »	23 32	23 4	48 4	Cep
15	» 20 »	1 53	1 44	59 20	Cas
18	Feb. 12, 1926	4 8	5 2	38 53	Aur
19	» 14 »	6 25	4 42	36 0	Aur
20	March 7 »	6 35	5 18	41 44	Aur
21	Sept. 1 »	20 16	20 36	32 50	Cyg
22	» 2 »	21 44	22 8	56 20	Cep
24	Oct. 11 »	0 57	1 40	55 50	Cas

δ Cep) five plates are placed. The third region is situated in *Cassiopeia* near ε Cas at 98° gal. long. Here only three plates are taken. Finally one region was chosen in *Auriga* at μ and η Aur. The three plates of this region cover, partly a very rich, partly a poor region; the galactic longitude is about 134°. (The coordinates of the galactic pole are assumed to be $\alpha = 190^\circ$, $\delta = +28^\circ$.) The angle at the sun between the regions in Cygnus and Auriga is 90°, thus a whole quadrant of the Milky Way is comprised in the investigation. The distribution of the stars can, consequently, be studied in rather different directions.

As is seen in Fig. 1 the plates of each region partly overlap. This is of importance for obtaining a comparison of spectra and magnitudes from different plates, in order to avoid systematic differences in the spectral classification and magnitude determinations.

The number of stars on the plates varies, of course, considerably from one plate and another. In the mean each plate contains about 700 stars for which the spectra are measurable. A very great number of the stars, at least 50 per cent, are *B* and *A* type stars. In the present investigation only *B* and *A* stars are treated although on most plates all the stars were classified.

3. *The spectral classification of the white stars.* Some years ago Professor LINDBLAD introduced a special classification of the early type stars¹ beside

¹ LINDBLAD, Spectrophotometric determinations of stellar luminosities, the distances and tangential velocities of stars in the Greenwich polar zone, *Nova Acta Reg. Soc. Sc. Ups.*, IV, 6, No. 5 (1925). Researches based on determinations of stellar luminosities, *Nova Acta etc.*, Vol. extra ordinem editum 1927, *Medd. fr. Astr. observ. Upsala*, No. 11 (1926).

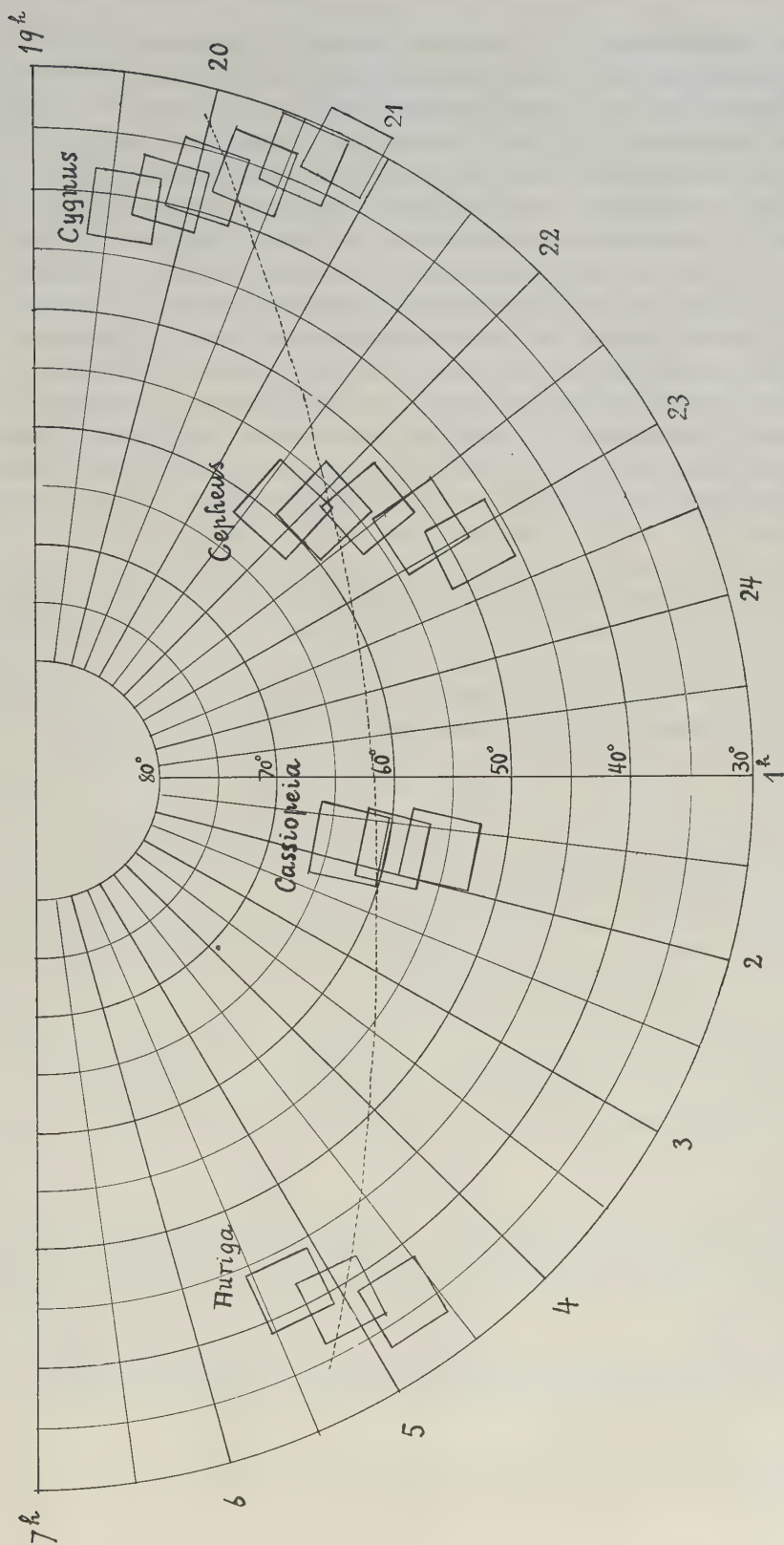


Fig. 1. The approximate position of the plates in the four galactic regions. (The dotted line is the galactic plane; the coordinates of the pole of the galaxy are supposed to be $\alpha = 12^h 40^m = 190^\circ$; $\delta = +28^\circ$.)

the Harvard classification. This special classification was used by him in his researches on stars in the Greenwich zone, and was also used by the author for the determination of absolute magnitudes for *B* and *A* stars.¹ The purpose of this division of the *B* and *A* stars into a number of sub-classes is to bring together within each class stars with nearly constant intrinsic luminosity. In the classification used at Upsala for the white stars the most important factor is the estimation of the width of the hydrogen lines $H\gamma$ and $H\delta$, which depends on the pressure-gradient in the outer layers of a star, thus, according to EDDINGTON, on the absolute magnitude. As to the physical and astrophysical basis for such determinations of absolute magnitudes from spectroscopic criteria depending on pressure I refer to the first-mentioned of the papers of LINDBLAD. Besides the sharpness of the hydrogen lines the colour of the stars is estimated by comparing in successive images the density in two spectral regions $H\gamma - \lambda 4400$ and $H\epsilon - H\zeta$; the zero of colour is defined by an average star of classes $\sigma+$ or σ . The definition of the luminosity groups is given completely in the following scheme of classification²:

- Class τ : The hydrogen lines are very narrow, so that they are invisible or almost invisible at the present dispersion.
- $\tau-$: The hydrogen lines are very narrow, but appear sufficiently clearly to be fixed without difficulty.
- $\sigma+$: The hydrogen lines are somewhat wider, but do not increase materially in width from strong to weak images of a sequence.
- σ : The hydrogen lines increase somewhat in width towards fainter images.
- $\sigma-$: The sharpness of the lines is less pronounced but is still noticeable. The colour is always low.
- ϱ : The wings of the hydrogen lines are strong. The colour is low.
- μ : The wings of the hydrogen lines are very strong, and the colour may be slightly more advanced.
- $\kappa-$: The colour is perceptibly more advanced than in the preceding classes. The hydrogen lines are winged.
- κ : The colour is considerably more advanced than in classes $\varrho-\mu$. The absorption at $\lambda 3906$ due to arc lines of Si and Fe is often marked.

When estimating the degree of sharpness of the hydrogen lines the blackness of the images must be taken into consideration. This is easily done on account of the series of images present for every star. — In many cases the lines of the $\kappa-$ and κ stars do not appear more winged than those of the σ

¹ SCHALÉN, Spectrophotometric determinations of absolute magnitudes of B and A type stars, Arkiv för matem., astr. o. fys., 19 A, No. 33, Medd. fr. Astr. observ. Upsala, No. 10 (1926).

² LINDBLAD and SCHALÉN, The luminosities, individual parallaxes, and motions of B and A type stars, Arkiv etc., 20 A, No. 7, Medd. etc. No. 17 (1927).

and σ - stars but seem to be rather narrow. It is, however, not possible to confuse these types because of the difference in colour and also because the K line is in most cases visible in the κ - and κ stars. The difference in colour is evident from ÖHMAN's diagrams in his photometric studies of effects of luminosity.¹ The measurement of the colour is rather difficult, it is true, as the two regions of the spectrum considered are widely separated. But these colour estimates are not used here in any computations but are only a simple means for separating the stars.

The classification of the stars in the usual Harvard types is performed by observing the strength of certain lines. The B stars are separated from the A stars by means of the helium line at $\lambda 4026$ which is strong in the early B stars. As the spectra are very short and narrow it is not possible, however, to separate the different sub-groups of the B stars. They are all denoted by B . The A stars are separated into the groups $B 8$, $A 0$, $A 2$, and $A 3$ by observing the strength of the K line in relation to the hydrogen lines.

I think that this method of using a series of narrow spectra for the classification of the stars is especially suited for statistical works of the present kind. *It is possible to reach rather faint stars with moderate exposure-time, and the classification is performed conveniently and very rapidly*, which is necessary when we have to deal with the »Durchmusterung» of several thousand stars. The accuracy of the spectral classifications will be discussed in the next paragraph.

4. *The mean error in the determinations of the special spectral types has been determined from a comparison between the types of stars classified on two plates independently.* The classifications of two overlapping plates have always been performed at rather long intervals of time, other plates having been classified in the interval. The spectral determinations for a star occurring on two plates can thus be considered as quite independent, and, consequently, a comparison of these types may give an idea of the accuracy of the method of classification in the luminosity groups. All the stars for which two determinations of spectral type were available were arranged according to the definitive luminosity type, that is the type finally used in the computations and in the catalogue. For every star the difference between the two determinations of luminosity type was taken. This difference was designed according to the following principle: Each step in the series of classes was denoted by 1, except the steps σ to σ - and ϱ to μ which were denoted by 0. Thus, e.g., if a star was classified σ on one plate σ - on the other the classifications were considered in full agreement. This is legitimate because the mean absolute magnitude is the same for the groups σ and σ - and also (nearly) for the groups ϱ and μ . We then have the scheme:

¹ ÖHMAN, Photometric studies of effects of luminosity and colour in short stellar spectra, Arkiv etc., 20 A, No. 23, Medd. etc., No. 33 (1927).

Type	τ	$\tau-$	$\sigma+$	$\sigma, \sigma-$	ϱ, μ	$\kappa-$	κ
Interval	$\left\{ \begin{array}{ccccccc} & & & 0 & 0 & & \\ & 1 & 1 & 1 & 1 & 1 & 1 \end{array} \right.$						

In the following Table 1 the mean errors are given calculated from these differences in the classifications on two plates.

Table 1.

Mean errors of the special luminosity classes.

Class	Error	Number of stars
$\tau, \tau-$	0.5	353
$\sigma+ \text{ to } \sigma-$	0.8	418
ϱ, μ	0.8	286
$\kappa-, \kappa$	0.8	198
All stars	0.75	1255

The mean error of the group $\tau, \tau-$ is small, and this is partly due to the circumstance that the group τ is the limit of the series so that a star cannot be confused with any other type but $\tau-$ (possibly but very seldom $\sigma+$). The mean error is, therefore, not quite comparable with the mean error for the groups $\sigma+ - \sigma-$ and $\varrho - \mu$ but I think, nevertheless, that it has some signification, for the groups τ and $\tau-$ are well defined and mistakes are rare. For all the stars together the mean error is only 0.75 of an interval which can be considered very satisfactory.

Table 2.

The number of stars of different spectrum (according to Harvard) and luminosity class (according to Upsala, this research).

Lum. class \ Harv. sp.	B 0—B 5	B 8—A 0	A 2—A 3	A 5—F 0
$m < 10.0$				
$\tau, \tau-$	242	148	23	8
$\sigma+ \text{ to } \sigma-$	8	385	69	8
ϱ, μ	—	189	70	8
$\kappa-, \kappa$	—	55	140	34
$m \geq 10.0$				
$\tau, \tau-$	46	21	2	6
$\sigma+ \text{ to } \sigma-$	4	61	22	7
ϱ, μ	—	62	41	10
$\kappa-, \kappa$	—	18	26	18

In order to show the correlation between the Harvard type and luminosity class I have collected in Table 2 all the stars for which the Harvard spectrum is available, according to the Henry Draper Catalogue and Extension. This table shows that the majority of the absolutely brightest stars are early *B* stars even if a great number of them also belong to the classes *B* 8—*A* 0. The majority of the $\sigma + - \sigma -$ stars are *B* 8—*A* 0 stars, while among the $\varrho - \mu$ stars many *A* 2—*A* 3 stars also occur. Most of the $\alpha -$, α stars belong to the *A* 2—*A* 3 types.

CHAPTER III.

The Photographic Magnitudes.

A. The apparent magnitudes.

1. As was said in the preceding chapter this research embraces stars of types *B* and *A* only. The apparent photographic magnitudes of these stars have been determined directly from measures on the spectrum plates. The magnitudes thus obtained are of sufficient accuracy to be used for statistical purposes.

We have for every star on the plate a series of images of decreasing exposure-time, a time scale, where the ratio between the exposure-time of two successive images is $= 2$. Let us denote the density (s) of a certain region of the 40^m -image with 1.0, the density of the 20^m -image with 2.0, and so on. When the quantity s increases with one unit the logarithm of the exposure-time (t) decreases with 0.3, and we may write:

$$\Delta s = - \frac{\Delta \log t}{0.3}. \quad (1)$$

The part of the spectrum which was chosen for density measurements is that between $H\gamma$ and $H\delta$. Within this interval of the spectrum, the effective wave-length of the white stars is to be found, and this region is always in good focus. As comparison image a spectrum of an *A* star was used. The density measurements were then performed in the following way. The density in the region $H\gamma - H\delta$ of the reference spectrum was simply compared with the density in the same region of the star on the plate, and the measured density was, according to the above agreement, called 1 with a decimal when the density of the reference spectrum was smaller than that of the first image in the scale of the star, but larger than that of the second, and so on. These density measurements are very easy to perform. — I have used not only one reference spectrum but three images of different degrees of blackening. For bright stars a measurement was made with each of these images, and the magnitude could be deduced from three measure-

ments; for fainter stars naturally only the faintest or the two faintest reference spectra could be used.

In order to derive the photographic magnitudes from these density measurements it will be necessary to start from a certain density law.

For this purpose I have employed the usual SCHWARZSCHILD law that may be written

$$I^q \cdot t = \text{const.} \quad (2)$$

or

$$\log (It) = \text{const.} + (1-q) \log I.$$

This law is, it is true, only a special case of a more general law as pointed out by KRON¹ and discussed by HALM², namely

$$\log (It) = \text{const.} + \log (aI^\alpha + bI^{-\alpha}).$$

This general law was first used (putting $b = a$) but it showed itself as quite sufficient for my purpose to apply the more simple law.

Introducing in (2) the density according to formula (1) and the apparent magnitude defined through the relation

$$m = \text{const.} - 2.5 \log I$$

we easily find

$$s = C - \frac{4}{3} q \cdot m. \quad (3)$$

Thus, if we know the magnitudes of at least two stars on the plate, the constants C and q of formula (3) can be determined from the measured densities s of these stars. (The application of KRON's formula would signify that in (3) a third small term had to be introduced containing a third constant, the determination of which is, however, very doubtful.)

In reality there are at least 20 or 30 stars on each plate with well-known magnitudes, according to photometric measurements at Harvard. I have thus determined C and q for each plate through a least square solution.

2. The standard stars used for the determination of the constants of formula (3) have been taken from Harv. Annals 50 that contains stars brighter than mag. 6.5, and Harv. Annals 54 with stars fainter than mag. 6.5. Nearly all these stars are listed in the Draper catalogue. Finally, also, a small number of stars from Harv. Annals 70 have been used. This catalogue contains the magnitudes of fainter stars in certain Durchmusterung zones. Between the magnitudes of H.A. 70 and H.A. 54 NORT has found a slight systematic

¹ KRON, Über das Schwärzungsgesetz photographischer Platten, Publ. des astrophys. Observatoriums zu Potsdam, No. 67 (1913).

² HALM, On the determination of fundamental photographic magnitudes, Month. Not., 75, 150 (1915). — On the determination of photographic magnitudes, Month. Not., 78, 379 (1918).

difference.¹ This small correction has not been applied here. For several plates the constants were calculated both with and without this correction; as the number of stars from H.A. 70 used here is very small, the difference between the results is negligible.

From the visual magnitude, as given in the catalogue, the photographic magnitude was computed using the colour indices of the Draper catalogue. For stars not listed in the Draper catalogue the colour indices given in Table 3 were used. The distance of each standard star from the centre of the plate

Table 3.

Colour indices.

Type	<i>B</i>	<i>B8</i>	<i>A0</i>	$\alpha -$	α
C.I.	-0.2	-0.1	0.0	+0.1	+0.1

was measured, and the centre correction as given in Table 4 below, was added to the photographic magnitude. Then the density measured s corresponds to a definite photographic magnitude independent of the situation of the star on the plate. C and q were then calculated from formula (3) through a least square solution for every plate, a mean value was taken for q (as it showed itself that q varies very little from one plate and another) and then C was computed with this value. The mean value of q from all the plates is

$$q = 1.27 \pm 0.046 \text{ (m.e.)}$$

corresponding to the SCHWARZSCHILD exponent

$$p = 1/q = 0.79 \pm 0.029.$$

According to that the magnitudes for the other stars on the plate were obtained from the formula (photographic magnitudes on Harvard visual scale)

$$m = 0.59 (C - s). \quad (4)$$

Such a formula was deduced for each of the three comparison images used, so that the magnitude for every star not too faint was obtained from two or three measures.

3. Centre correction. In his research on effective wave-lengths for stars in Aquila² PETERSSON has derived a curve which gives the centre correction as a function of the distance of the star from the centre of the plate. I have used this centre correction here. I have also tried to test the results of

¹ See PANNEKOEK, *Researches etc.* p. 26, Publ. of the Astron. Institute of the Univ. of Amsterdam, No. 1 (1924).

² PETERSSON, *Effective wave-lengths of faint Milky Way stars in Aquila*, Arkiv för Matem., astr. & fys., 19 A, No. 3 (1925).

PETERSSON. On one of my plates there are about fifty stars with well-known magnitudes. For this plate I derived, in the same manner as PETERSSON, a centre correction, and I got very nearly the same result.

Table 4.

Centre correction.

Dist. from centre (cm)	0.0—2.1	2.1—4.5	4.5—5.9	5.9—7.1	7.1—8.2
Correction (mag.)	0.0	0.1	0.2	0.3	0.4

As the magnitudes are to be determined only in tenths of a magnitude, the corrections tabulated in Table 4, were employed. This centre correction has to be subtracted from the magnitude computed from formula (4).

4. *Comparison of results from different plates.* As was said above the plates of each of the four Milky Way regions are partly overlapping. Consequently it was made possible to compare the magnitude determinations for stars occurring on two plates, whose magnitudes are measured twice independently. In this manner systematic differences of the scales of different plates can be avoided. In each region one of the plates was taken as the standard plate to which the determinations of the other plates were corrected. Finally, regarding the corrections the condition was observed that the sum of them should be equal to zero, for each set of plates (each region). The corrections to be applied were small, never exceeding 0.2 mag.

From the comparison of the determinations from different plates the mean error of the magnitudes could be deduced. These mean errors are given in Table 5 together with the number of stars in parentheses from which each

Table 5.

Mean errors of the photographic magnitudes.

Mag. on Harv. visual scale	Cygnus	Cepheus	Cassiopeia	Auriga	All stars
$m_{ph} \leq 7.5$	0.15 (43)	0.13 (28)	0.14 (11)	0.16 (7)	0.15 (84)
$7.6 \leq m_{ph} \leq 8.5$	.15 (58)	.15 (24)	.12 (18)	.13 (14)	.14 (114)
$8.6 \leq m_{ph} \leq 9.5$	.15 (147)	.12 (89)	.12 (69)	.14 (22)	.13 (327)
$9.6 \leq m_{ph} \leq 10.5$	.15 (270)	.15 (173)	.12 (158)	.13 (56)	.14 (657)
All stars	0.15 (518)	0.14 (309)	0.12 (256)	0.14 (99)	0.14 (1182)

figure is calculated. The mean is 0.14 mag. which shows that the magnitudes have been obtained with a sufficient degree of accuracy for the statistical treatment of the material.

5. *Reduction of the magnitudes to the International scale.* The magnitudes hitherto obtained were based on the Harvard visual scale. It is desirable to give the magnitudes reduced to the International scale.

The correction of the magnitudes to the International scale was derived in two ways.

a) From a comparison with the stars in the Henry Draper Extension of the Cygnus region¹; these magnitudes are based on the International scale. About 600 stars are common with mine. In order to examine, at the same time, if there could be any influence of spectral type in my magnitude determinations, as the magnitudes are determined directly from the spectra, the material was grouped according to the spectral type of the »Extension» into four groups, namely *B0—B5*, *B8—A0*, *A2—A3*, *A5—F0*. Furthermore the stars were separated into magnitude groups according to the quantity $\frac{1}{2}(m_{\text{Ext}} + m_{\text{Sch}})$. In Table 6 below the differences $m_{\text{Ext}} - m_{\text{Sch}}$ and dispersions are given

Table 6.
Comparison with Henry Draper Extension.

Mag.	<i>B0—B5</i>		<i>B8—A0</i>		<i>A2—A3</i>		<i>A5—F0</i>		All stars	
$\bar{m} < 9.0$	+0.23	0.89 (13)	+0.05	0.28 (14)	+0.40	0.28 (8)	±0.00	(1)	+0.19	0.35 (86)
$9.0 \leq \bar{m} \leq 9.45$	+0.21	0.87 (32)	+0.26	0.32 (49)	+0.22	0.36 (27)	+0.12	0.26 (9)	+0.23	0.35 (117)
$9.5 \leq \bar{m} \leq 9.95$	+0.16	0.26 (25)	+0.30	0.28 (83)	+0.29	0.22 (57)	+0.20	0.20 (27)	+0.27	0.26 (192)
$10.0 \leq \bar{m} \leq 10.45$	+0.24	0.26 (28)	+0.24	0.26 (94)	+0.32	0.24 (65)	+0.27	0.20 (24)	+0.27	0.25 (211)
$\bar{m} \geq 10.5$	+0.40	0.24 (4)	+0.48	0.24 (45)	+0.56	0.28 (12)	+0.50	0.35 (7)	+0.49	0.26 (68)

with the corresponding number of stars within brackets. It is found from this table that the differences between the magnitudes in »Extension» (International scale) and my magnitudes (Harvard visual scale) are all positive amounting to 0.2 à 0.3 mag. — A result of great importance which is obtained from Table 6 is that *there is no pronounced run in the differences with spectral type*. In some of the magnitude groups there is a slight increase of the differences from the *B* stars to the *B8—A0* and *A2—A3* groups. But for the *A5—F0* stars the differences again are smaller so that the change does not run parallel with the change of spectrum. In any case it is evident that no correction is needed on this account.

b) From stars in Harvard standard regions.² In the catalogue of these regions there are given the visual magnitude on the Harvard scale and the Harvard photographic magnitude. If the visual magnitude be corrected for colour index and the photographic magnitude for the correction in Harvard Bull. 781 we get the photographic magnitudes on the Harvard scale and the

¹ Harvard Annals, 100, No. 1 (1927).

² Harvard Annals, 71.

International scale. A comparison between these magnitudes will give the required difference between Harvard visual and International scale. Stars of spectral types earlier or equal to $A5$ given in the northern standard regions were used. They were grouped according to the values $\frac{1}{2}(m_{\text{Harv.}} + m_{\text{Int.}})$. The differences (and dispersions) given in Table 7 were obtained between the Inter-

Table 7.

International scale—Harvard visual scale, from Harvard Standard Regions.

m_{ph}	$6.0 \leq \bar{m} \leq 6.99$	$7.0 \leq \bar{m} \leq 7.99$	$8.0 \leq \bar{m} \leq 8.99$	$9.0 \leq \bar{m} \leq 9.8$	$\bar{m} > 9.8$
Diff. (mag.)	-0.03 0.13 (6)	-0.09 0.19 (23)	+0.05 0.15 (13)	+0.18 0.27 (17)	+0.30 0.11 (6)

national scale and Harvard visual scale. The differences for stars fainter than mag. 9.0 may serve as a test for the correction derived from the comparison with Harvard Extension. Thus we shall have to apply a correction of about +0.2 for stars of mag. 9.0 and a correction amounting to nearly +0.3 for stars of mag. 10. As to the correction for brighter stars this is, of course, a little uncertain derived from a relatively small number of stars in Harvard standard regions. Let us, however, compare our results with those obtained by SEARES¹ in his researches on the relation between the Harvard scale and International scale. The correction of 0.2—0.3 mag. for magnitudes 9—10 is in full agreement with SEARES' results. For magnitudes 9.5—10.0 his correction curve reaches a maximum and then decreases again. It is clear that in my case we have to use a linear correction curve as my magnitudes are based on stars brighter than mag. 10; this is also evident from Table 6 for faint magnitudes. For bright magnitudes the correction decreases to zero at mag. 6. This is in rather good agreement with the results obtained in Table 7.

In accordance with the previous results and those of SEARES I have applied the corrections given in Table 8 for the reduction of the magnitudes to the International scale. They represent a linear correction curve.

Table 8.

Definitive corrections of magnitudes to the International scale.

m_{ph} (Harv. vis.)	< 5.3	5.3—6.7	6.7—8.3	8.3—9.8	> 9.8
Corr. (mag.)	-0.1	0.0	+0.1	+0.2	+0.3

The correction of the magnitudes to the International scale causes a change in the value of the SCHWARZSCHILD exponent. We have

$$p = - \frac{\Delta \log I}{\Delta \log t}.$$

p can be determined from density measurements on stars of different mag-

¹ SEARES, Some relations between magnitude scales, Mount Wilson Contr., No. 288, Astrophys. Journal, 61, 284 (1924).

nitude. Let us take a star of mag. 6.0 and another of mag. 9.0 in the Harvard scale. The magnitude of the former will be unchanged, that of the latter corrected by $+0.2$. Thus the difference Δm will get a correction $+0.2$ and $\Delta \log I$ a correction $-2/25 = -0.08$ (which, of course, does not mean a real change of intensity). The difference $\Delta \log t$ will naturally in both cases be the same. Thus we have, denoting the two exponents with p_1 and p_2 ,

$$p_1 = + \frac{0.4 \cdot 3.0}{[\Delta \log t]_1}; \quad \because [\Delta \log t]_1 = \frac{1.20}{p_1}$$

$$p_2 = - \frac{[\Delta \log I]_2}{[\Delta \log t]_2} = - \frac{[\Delta \log I]_1 - 0.08}{[\Delta \log t]_1} = p_1 + \frac{0.08}{[\Delta \log t]_1}$$

$$= p_1 \left(1 + \frac{1}{15} \right).$$

The correction to the value of p derived previously is thus $1/15 \cdot p$ and the new value of the SCHWARZSCHILD exponent will be $p = 0.84$.

B. The absolute magnitudes.

Determinations of mean absolute magnitudes for the different luminosity groups of the *B* and *A* type stars have been performed at Upsala by LINDBLAD and the author. The results have been published in two papers from 1926 and 1927.¹

In my investigation from 1926 the results for the absolute magnitudes were derived partly from a study of the parallax motion of Boss stars, partly from stars belonging to the Pleiades group and the moving cluster in Perseus. A rather detailed comparison was made with results obtained by others especially with results derived by ADAMS and JOY. The agreement between our results was very satisfactory.

In the second paper (in 1927) the material was considerably increased both as regards the Boss stars and the group stars. Stars belonging to the Hyades, Praesepe, and Coma Berenices clusters were also used. The aim of that investigation was to determine a possible correction of the results arrived at in the first paper. — For further details I refer to the two papers mentioned.

The mean absolute photographic magnitudes M_0 for the luminosity groups used in the present paper are the following in agreement with Table III of Meddelanden 17:

Group	τ	$\tau -$	$\sigma +$	$\sigma, \sigma -$	ϱ, μ	$\kappa -$	κ
M_0 (phot)	-3.3	-1.7	-0.4	+0.3	+1.0	+1.9	+2.5.

It is thus assumed that the colour indices are in the mean -0.1 for τ and

¹ Loc. cit.

$\tau-$, 0.0 for $\sigma+$ to μ , and +0.1 for $\kappa-$ and κ . The $\kappa-$ stars are, in the computations, all considered as $A2\kappa-$ (the number of $A0\kappa-$ stars is small), and for $A2\kappa$ and $A3\kappa$ the same mean value is assumed.

The dispersion within each of the groups $\tau-$ to κ is =0.5 according to the results of the cited papers. For the group τ the dispersion is assumed to be =0.7.

For the computation of the distances in the catalogue somewhat more detailed magnitudes have been used, thus for ϱ +0.9, μ +1.0, for $A0\kappa-$ +1.4, $A2$, $3\kappa-$ +1.9, for $A2\kappa$ +2.4, and $A3\kappa$ +2.6.

CHAPTER IV.

The Derivation of the Star-densities.

1. The derivation of the space density on the basis of the apparent distribution of the stars is often performed under a presumption as to the analytical form of the density function $D(r)$. The coefficients of this function are deduced from the known coefficients of the functions $b(m)$ and $\varphi(M)$, the frequency functions of the apparent and absolute magnitudes.

A common assumption as to $D(r)$ is

$$D(r) = e^{h+k\varrho+l\varrho^2},$$

where

$$\varrho = 5 \log r,$$

for if the functions $b(m)$ and $\varphi(M)$ can be expressed by similar functions in m and M respectively, the relation connecting these three functions:

$$b(m) = \omega \int_0^\infty D(r) \varphi(M) r^2 dr$$

implies such a form for $D(r)$ according to SCHWARZSCHILD (cf. ch. I).

For detailed studies of the very complicated distribution of the stars in or near the galactic plane, it cannot be considered appropriate to start from an analytically given form of the density function. I have, therefore, at the computation of the space density used a procedure suggested by LINDBLAD¹, and analogous to that employed by KAPTEYN, for the derivation of the star-densities within 1000 parsecs from the sun (see ch. I). The advantage of this method is that *no presumption is made on the form of the density curve.*

2. The procedure is, in a few words, the following. The stars of the spectral group considered (*e.g.* one of the luminosity groups of the white stars)

¹ LINDBLAD, On the decrease of star-density etc. Arkiv för matem., astr. & fys., 19 B, 15. Medd. fr. Astr. observ. Upsala, No. 29 (1927).

are distributed in a table with double entry, in one direction apparent magnitudes, in the other absolute magnitudes. For successive values of the apparent magnitudes the stars are distributed around a mean absolute magnitude according to a normal error curve; the computation of this mean magnitude for a given apparent magnitude is made according to MALMQUIST's relations. The »(m, M)-table» is easily transformed into a »(m, r)-table» where the entries are m and r . Thus we get in this table the number of stars of different apparent magnitudes within successive intervals of distance. Summing up for all apparent magnitudes the required total number of stars, within successive distance intervals, is obtained.

The only presumption in this method is that the absolute magnitudes for the group of stars investigated are distributed according to a normal error curve

$$\varphi(M) = \frac{1}{\sigma \sqrt{2\pi}} e^{-\frac{1}{2\sigma^2}(M-M_0)^2} \quad (1)$$

As the dispersion σ within each of the luminosity classes is small it follows from MALMQUIST's researches¹ that the frequency function of stars of a constant apparent magnitude is also a normal error curve, say

$$\varphi_m(M) = \frac{1}{\sigma_m \sqrt{2\pi}} e^{-\frac{1}{2\sigma_m^2}(M-\bar{M}_m)^2} \quad (2)$$

The quantities $\bar{M}_m$ and σ_m are defined through the relations

$$\bar{M}_m = \frac{\int_0^\infty D(r) \varphi(M) M r^2 dr}{\int_0^\infty D(r) \varphi(M) r^2 dr},$$

$$\sigma_m^2 = \frac{\int_0^\infty D(r) \varphi(M) (M - \bar{M}_m)^2 r^2 dr}{\int_0^\infty D(r) \varphi(M) r^2 dr},$$

which give, as was shown by MALMQUIST,

¹ MALMQUIST, A study of the stars of spectral type A, Meddelanden från Lunds astr. observ., II, 22 (1920). — On some relations in stellar statistics, Arkiv för matem., astr. & fys., 16, No. 23, Medd. fr. Lunds astr. observ., No. 100 (1922).

$$\left. \begin{aligned} \overline{M}_m &= M_0 - \frac{\sigma^2}{\log e} \frac{d \log b(m)}{dm} \\ \sigma_m^2 &= \sigma^2 + \frac{\sigma^4}{\log e} \frac{d^2 \log b(m)}{dm^2} \end{aligned} \right\} \quad (3)$$

These relations are valid for an arbitrary density function. On account of the small dispersions we have, in our case, always $\sigma_m = \sigma$.

3. The direct relation between the functions $\varphi(M)$ and $\varphi_m(M)$ is the following. $\varphi_m(M) dM dm$ means the proportion of stars whose absolute magnitudes lie between M and $M + dM$ and whose apparent magnitudes lie between m and $m + dm$. This proportion is¹

$$\varphi_m(M) dM dm = \frac{\omega}{5 \log e} 10^{-0.6(M-m-5)} D[10^{-0.2(M-m-5)}] \varphi(M) dM dm \quad (4)$$

and we have, consequently, the relation

$$\varphi_m(M) \sim \varphi(M) \cdot 10^{-0.6(M-m-5)} D[10^{-0.2(M-m-5)}]. \quad (5)$$

From this relation the connection between the constants of $\varphi(M)$ and $\varphi_m(M)$ can be derived for different assumptions as to the function $D(r)$. *E.g.*, if we assume that

$$b(m) = b_0 e^{-\frac{1}{2\beta^2}(m-m_0)^2}$$

and that $\varphi(M)$ has the form (1) we know that

$$D(r) = D_0 e^{-\frac{1}{2\alpha^2}(\varrho-\varrho_0)^2}.$$

We then get from (5)

$$e^{-\frac{1}{2\sigma_m^2}(M-\overline{M}_m)^2} \sim e^{-\frac{1}{2}\left(\frac{1}{\sigma^2} + \frac{1}{\alpha^2}\right)\left[M - \frac{2\alpha^2\sigma^2}{\alpha^2+\sigma^2}\left(\frac{M_0}{2\sigma^2} + \frac{m+5-\varrho_0}{2\alpha^2} - \frac{0.3}{\log e}\right)\right]^2} + \dots,$$

from which

$$\begin{aligned} \overline{M}_m &= \frac{1}{\alpha^2 + \sigma^2} \left[\alpha^2 M_0 + \sigma^2 (m+5-\varrho_0) - \frac{0.6}{\log e} \alpha^2 \sigma^2 \right], \\ \sigma_m^2 &= \frac{\alpha^2 \sigma^2}{\alpha^2 + \sigma^2}. \end{aligned}$$

Observing that we have the following relations between $m_0, \beta, \alpha, \varrho_0, \sigma$, and M_0 :

$$\begin{aligned} \beta^2 &= \alpha^2 + \sigma^2 \\ m_0 &= M_0 + \varrho_0 - 5 + \frac{0.6}{\log e} \alpha^2, \end{aligned}$$

¹ SCHWARZSCHILD, Zur Stellarstatistik, Astr. Nachr., No. 4557 (1911). — SEARES, Remarks on the luminosity and density functions, Astrophys. Journal, 59, 11, Mount Wilson contr., No. 271 (1924).

we may also write:

$$\overline{M}_m = M_0 + \frac{\sigma^2}{\beta^2} (m - m_0),$$

$$\sigma_m^2 = \sigma^2 \left(1 - \frac{\sigma^2}{\beta^2} \right).$$

As we have in this case

$$\frac{1}{\log e} \frac{d \log b(m)}{dm} = - \frac{m - m_0}{\beta^2}$$

$$\frac{1}{\log e} \frac{d^2 \log b(m)}{d m^2} = - \frac{1}{\beta^2}$$

the relations can also be written in the form (3).

4. Let us consider one of the luminosity classes τ , $\tau -$, $\sigma +$, etc. For this group we know M_0 and σ , the mean value of the absolute magnitudes and the dispersion around this mean. If we count the number of stars N_m of successive apparent magnitudes we get, approximately, the function $b(m)$. According to (3) the characteristics of the »apparent luminosity curve» $q_m(M)$ can be computed for different m . In this paper the derivative $\frac{d \log b(m)}{d m}$ could, in most cases, be taken $= \text{const.}$, and thus the same value M_m could be used for all m . σ_m is always $= \sigma$.

After having computed $\overline{M}_m$ and σ_m the counted number of stars N_m of mag. m is distributed around $\overline{M}_m$ according to the formula (2). If we put the interval dM equal to δ and compute the number of stars in each of the intervals $\overline{M}_m$ to $\overline{M}_m + \delta$ and $\overline{M}_m$ to $\overline{M}_m - \delta$ we find, as the mean magnitude in each of the intervals is $\overline{M}_m \pm \frac{1}{2} \delta$

$$N_m^{(\frac{\delta}{2})} = N_m \cdot \frac{1}{\sigma_m \sqrt{2\pi}} e^{-\frac{1}{2\sigma_m^2} \left(\frac{\delta}{2}\right)^2} \cdot \delta. \quad (6)$$

In the intervals $\overline{M}_m + \delta$ to $\overline{M}_m + 2\delta$ and $\overline{M}_m - \delta$ to $\overline{M}_m - 2\delta$ we get

$$N_m^{(\frac{3}{2}\delta)} = N_m \cdot \frac{1}{\sigma_m \sqrt{2\pi}} e^{-\frac{1}{2\sigma_m^2} \left(\frac{3}{2}\delta\right)^2} \cdot \delta, \quad (6 \text{ a})$$

and so on. — The interval δ is, appropriately, chosen equal to the interval between the successive apparent magnitudes for which counts are made.

The transformation of the (m, M) -table into a distance table is, of course, easy to perform, as we know both the apparent and absolute magnitude corresponding to every star-number $N_m^{(\frac{\delta}{2})}$ etc. We then get the total number of

stars in different intervals of distance. Let this number be N_{r_1, r_2} between the distances r_1 and r_2 parsecs in the cone of observation considered. Now the volume limited by two planes at right angles to the line of sight at distances r_1 and r_2 is

$$V_{r_1, r_2} = \frac{\omega}{3} (r_2^3 - r_1^3) \text{ parsecs}^3 \quad (7)$$

where ω is the solid angle of the cone of observation. This quantity can be computed in the following way. From the known focal-length of the instrument used it is easy to find the area in square degrees of the sky occupied by a given plate area. As the whole sphere contains $360^2/\pi$ square degrees and corresponds to $\omega = 4\pi$, ω can be determined in each individual case.

By *absolute density* $D_{\text{abs.}}$ we mean in this paper the number of stars per 1000 cubic parsecs, and we have

$$D_{\text{abs.}} = 1000 \frac{N_{r_1, r_2}}{V_{r_1, r_2}}. \quad (8)$$

5. An example may best illustrate the foregoing procedure. Let us assume that we have the following numbers of stars of successive apparent magnitudes:

m	N_m	$\log N_m$
10.3	23	1.36
9.8	12	1.08
9.3	8	0.90
8.8	5	0.70
8.3	2	0.30
7.8	1	0.00

The function $b(m)$ is obtained from N_m , for we can assume $N_m = \frac{1}{2} b(m)$. If we draw a curve with m as abscissae and $\log N_m$ as ordinates we find that the points lie very nearly on a straight line. We get

$$\frac{d \log b(m)}{dm} = \frac{d \log N_m}{dm} = \text{const.} = 0.5.$$

If the stars belong to the group τ — we have

$$M_0 = -1.7; \quad \sigma = 0.5$$

and get from (3)

$$\bar{M}_m = -2.0; \quad \sigma_m = 0.5.$$

As the stars have been counted for each half magnitude we have $\delta = \frac{1}{2}$.

According to (6) and (6 a) and analogous expressions we find

$$N_m^{(1)} = 0.353 N_m$$

$$N_m^{(3)} = 0.130 N_m$$

$$N_m^{(3)} = 0.017 N_m.$$

The (m, M) -table has the following character:

(m, M) -table.

$M \backslash m$	7.8	8.3	8.8	9.3	9.8	10.3
					0.5	0.5
-1.0			0.5	1	1.5	3
-1.5	0.5	1	2	3	4	8
-2.0	0.5	1	2	3	4	8
-2.5			0.5	1	1.5	3
-3.0					0.5	0.5

From this table the following (m, r) -table is deduced.

(m, r) -table.

$r \backslash m$	7.8	8.3	8.8	9.3	9.8	10.3	10.8	Σ	$D_{\text{rel.}}$	$D_{\text{abs.}}$
	0.5							0.5	0.50	0.00066
912	0.5	1	0.5					2	1.00	0.00133
1148		1	2	1	0.5			4.5	1.12	0.00149
1445			2	3	1.5	0.5		7	0.88	0.00117
1820			0.5	3	4	3	(0.5)	11	0.69	0.00092
2291				1	4	8	(4)	18	0.56	0.00075
2884					1.5	8	(13)	32	0.50	0.00066
3631										

As in this case $\delta = \frac{1}{2}$, we have the ratio

$$r_n : r_{n+1} = 10^{-0.1}$$

between successive distances in the (m, r) -table, and hence the ratio between successive volumes is

$$\frac{V_{r_{n-1}, r_n}}{V_{r_n, r_{n+1}}} = \frac{r_n^3 - r_{n-1}^3}{r_{n+1}^3 - r_n^3} = \frac{1}{10^{0.8}} = \frac{1}{2}.$$

The relative densities D_{rel} are then obtained by dividing the star-numbers with 1, 2, 4, 8, . . . If the area considered here corresponds to 19.6 square degrees we find $\omega = 0.00596$. According to (7) the volume between two successive distances is computed, *e.g.* for $r_1 = 912$, $r_2 = 1148$, and then it is found that the two stars in this volume correspond to 0.00133 stars per 1000 cubic parsecs. The other absolute densities are computed from the corresponding relative densities.

In each horizontal line of the (m, r) -table the star-numbers should be distributed according to an error curve with mean M_0 and dispersion σ . For each horizontal line corresponds to a limited volume of space, and for such a volume the true luminosity curve is valid. For greater distances the star-numbers can be completed according to such a normal distribution as is seen from the table.

CHAPTER V.

Dark Nebulae and their Influence upon the Observed Distribution of the Stars.

The structure of the Milky Way is extremely complicated. The photographs of the Milky Way show, close by the most star-filled regions and brightest star-clouds, dark areas and rifts that seem to be nearly devoid of stars. In many cases the transition from rich to poor regions occurs very suddenly, so that a sharp limit is formed between the regions, in other cases there is a more gradual thinning out of the stars. The question naturally arises whether these dark areas are real empty spaces, or if, in the direction of the dark regions, the stars are hidden behind dark nebulae that absorb a greater or less percentage of the star-light.

The probable existence of extensive cosmic clouds was already pointed out by Sir WILLIAM HERSCHEL¹ in his studies on nebulae. He did not distinguish clearly between bright and dark nebulae, only between different degrees of visibility of the nebulous matter. In his above-mentioned paper HERSCHEL adds that »the range of visibility of the nebulous matter is confined to very moderate limits». — Among the first to look upon the dark

¹ W. HERSCHEL, Astronomical observations relating to the construction of the Heavens etc. Phil. Trans. 1811.

regions as real dark nebulae was A. C. RANYARD¹ who says about the dark markings south and east of θ Ophiuchi: »... seem to me to be undoubtedly dark structures, or obscuring masses in space...». Later on the dark regions of the sky were investigated by BARNARD who published a list² of 182 dark markings. BARNARD says he did not at first believe in these obscuring masses as the proof of their existence was not conclusive. »The increase of evidence, however, ... convinced me ... that many of these markings were not simply due to an actual want of stars but were really obscuring bodies nearer to us than the distant stars» (l. c., p. 12). Their apparent preference for the bright regions of the Milky Way is due to the fact that they are more easily shown with a bright back-ground.

In a number of papers Pater HAGEN has examined the dark nebulae.³ Pater HAGEN considers it possible to observe *visually* these cosmic clouds. He is of the opinion that the whole sky outside the Milky Way is covered with such cosmic clouds forming a great system, Via Nubila. The difficulty and delicate nature of such observations is evident, and has been discussed in the literature at various times. Especially LUNDMARK has pointed out this fact.⁴ He lays stress, and rightly, upon the necessity for the observations of Pater HAGEN being repeated by other observers, under other climatic circumstances, and with other instruments.

An extensive research on the distribution of dark nebulae on the basis of the Franklin-Adams plates has been undertaken by LUNDMARK and MELOTTE.⁵ Everyone of the 206 plates was closely examined by LUNDMARK and MELOTTE independently; every region, where the star-density is five or six times as small as in the surroundings, and where the transition from rich to poor regions occurs rapidly, has been noted and catalogued as a dark nebula. The majority of the dark nebulae on LUNDMARK's chart are situated in or near the Milky Way, perhaps owing, partly, to an effect of contrast.

Through all these researches *the existence of extensive dark nebulae cannot be doubted* even if some of the dark regions must, probably, be ascribed to real vacancies among the stars. WOLF has suggested the possibility that the caves, often seen near bright nebulae, are real vacant spaces formed through

¹ RANYARD, Knowledge, 17, 253 (1894).

² BARNARD, On the dark markings of the sky, Astrophys. Journ., 49, 1 (1919). Besides this paper articles in: Astrophys. Journ., 9, 157 (1899); 25, 218 (1907); 31, 8 (1909); 38, 496 (1913); 41, 253 (1915); 43, 1 (1916); Pop. Ast., 14, 579 (1906).

³ HAGEN, The papers are published in several scientific journals but are collected in the publication Miscellanea Astronomica, parte III (1924), art. 53—66, especially art. 53, Via lattea e via nubila. 55, Die dunklen kosmischen Nebel (Astr. Nachr., 5110, 1921); 56, Dunkle Nebel und Sternenleeren (Astr. Nachr. Jubiläumsnr. 1921); 62, Explanatory notes to the article of Dr. Lundmark (Pub. of Ast. Soc. of Pac., 34, 320, 1922).

⁴ LUNDMARK, Father Hagen's papers on dark nebulae, Pub. of Ast. Soc. of Pac., 34, 191 (1922).

⁵ LUNDMARK, De mörka nebulosornas utbredning, Pop. astr. tidskr., VII, p. 18. Meddel. fr. Astr. observ. Upsala, No. 12 (1926); Studies of anagalactic nebulae, First paper, Nova Acta Reg. Soc. Sc. Ups., Vol. extra ordinem editum 1927. Meddel. fr. Astr. observ. Upsala, No. 30 (1927).

some cosmic process, an idea taken up by COURVOISIER¹ for a hydrodynamic interpretation of the caves. In his later researches, concerning the dark places in different regions of the sky, WOLF also assumes the existence of dark cosmic clouds.²

Of what material are the dark nebulae composed? This question has not yet found its solution. I will briefly refer to the opinions of some investigators. In an interesting paper in 1922 H. N. RUSSELL³ discusses the composition of dark nebulae. The general conclusion of RUSSELL is that obscuration of light in space, whether general or selective, will be produced mainly by dust particles a few millionths of an inch in diameter. — EDDINGTON in his book, *Internal constitution of the stars*, assumed that the diffuse and dark nebulae are »local condensations of the general cloud of interstellar matter revealed by the fixed calcium lines».⁴ — In his studies of the dark nebula in Taurus, PANNEKOEK⁵ assumed that the absorption were due to scattering through the molecules of the gas cloud; using the formula of RAYLEIGH for the absorption coefficient PANNEKOEK found an extremely high mass of the nebula amounting to $4 \cdot 10^9$ solar masses. Assuming instead scattering by free electrons (which does not produce reddening of the light as does the RAYLEIGH scattering) EDDINGTON finds a mass of $1.2 \cdot 10^8$ solar masses. — WOLF has studied the composition of the dark nebulae by comparing the colours of the stars in bright and dark regions. He arrives at the following conclusion⁶: »Keineswegs macht der dunkle Nebel das Sternenlicht beim Durchgange röter. Es scheint also recht wahrscheinlich dass die lichtabfangende Wolke zum grössten Teil aus Staubmassen besteht.»

As to the possible existence of great quantities of meteoric matter in space, so that an appreciable extinction may be produced, I will mention the following circumstance: WIRTZ has found that the surface brightness of spiral nebulae decreases with increasing distance, the decrease being 0.02 mag. for a distance of 1000000 light-years. According to LUNDMARK⁷ this can be explained if the inter-nebular space contains a number of $0.6 \cdot 10^{16}$ meteors within a cube having a side of one astronomical unit. According to the researches

¹ COURVOISIER, Über die Gasnebel und die Konstitution der Milchstrasse, *Astr. Nachr.*, No. 4077 (1905). — WOLF, Über eine Eigenschaft der grossen Nebel, *Astr. Nachr.*, No. 3848 (1903).

² WOLF, Über den dunklen Nebel NGC 6960, *Astr. Nachr.*, No. 5239 (1923); Die Sternleeren beim Amerika-nebel, *Astr. Nachr.*, No. 5334 (1924); Die Sternleeren bei S Monocerotis, *Seeliger-Festschrift*, p. 312 (1924).

³ RUSSELL, Dark Nebulae, *Proc. of the Nat. Ac. of Sc. Wash.*, 8, 115 (1922).

⁴ EDDINGTON, *The internal constitution of the stars*, p. 388. Also the chapter »Absorption of light in space», p. 383—387.

⁵ PANNEKOEK, The distance of the dark nebulae in Taurus, Further remarks on the dark nebulae in Taurus, *Proc. of the Kon. Ak. van Wet. te Amsterdam*, 23, No. 5 (1920).

⁶ WOLF, *Loc. cit.* *Astr. Nachr.*, No. 5239.

⁷ LUNDMARK, The motions and the distances of spiral nebulae, *Month. Not.*, 85, p. 865 (1925).

of HOFFMEISTER¹ on the frequency of meteors the number should be 10^{16} within the same volume. The possible existence of meteor masses in space has also been pointed out by E. SMITH² and by P. SALET³.

V. RHIJN⁴ has studied the general absorption of light in space using the diameter-parallax curve of globular clusters. He finds an absorption of 0.0000355 mag. per parsec. From this he computes the density of particles in space (small meteoric particles) to be $4.7 \cdot 10^{-24}$ gr/cm³.

Thus, in general, the quantity of meteoric matter should be insufficient for causing an appreciable absorption of light within moderate distances, but it does not seem improbable that the strong absorption in certain dark regions of the sky is caused by agglomerations of meteoric matter.

2. Of course the study of the distance and absorption of the dark nebulae is of great importance for the problem of the distribution of the stars and the extension of the stellar system. Direct determinations of parallaxes of dark nebulae cannot be made. But the dark nebulae have a great influence upon the distribution of the stars as we observe it. Through a comparison between the area or space distribution of the stars in unobscured and obscured regions important conclusions can be drawn as to the distance and absorbing power of the nebula. This is one way and the most direct one. Another way presents itself in the circumstance that there are often stars showing a connection with bright or dark nebulae. An examination of the distance of such objects must, therefore, give valuable information as to the distances of the nebulae. For further information I refer to LUNDMARK's interesting paper on the parallaxes of bright and dark nebulae.⁵

In the present research the distances of dark nebulae in the Milky Way will be determined from studies of the distribution of the stars.

Let us consider two regions, one of which is covered by a dark nebula. The number of stars $B(m)$ to mag. m inclusive is counted in both regions. Then it will be found that the number of bright stars is, approximately, the same in both regions but, passing over a certain limiting magnitude, the number of stars of the dark region does not increase so rapidly as that of the unobscured region. This magnitude can be determined rather well, e.g. by graphical representation of the curve $\log B(m)$ in a diagram with m as abscissae (a method used by WOLF and others). If the mean parallax of stars of this magnitude is known the distance of the absorbing screen can be, approximately,

¹ HOFFMEISTER, Untersuchungen zur astronomischen Theorie der Sternschnuppen, Ergänzungshefte zu d. Astr. Nachr., 4, No. 5 (1922).

² E. SMITH, Occulting matter in space, Pop. Ast., 32, 265 (1924).

³ SALET, Sur l'absorption de la lumière des étoiles par les météorites, Bull. Astr., 28, 241 (1911).

⁴ V. RHIJN, On the absorption of light in space derived from the diameter-parallax curve of globular clusters. Bull. of the Astr. Inst. of the Netherlands, No. 141 (1928).

⁵ LUNDMARK, The parallaxes of bright and dark diffuse nebulae, Pub. of Astr. Soc. of the Pac., 34, 40 (1922).

determined. A better determination of the distance is, of course, obtained, if the examination of the $B(m)$ is performed for classes of stars with known mean absolute magnitude and with small dispersion of the absolute magnitudes. The absorbing power of the nebula expressed in magnitudes is obtained from the displacement along the axis of abscissae of the curve $\log B(m)$ for the dark region.

A method given by PANNEKOEK¹ for the determination of the distance and absorption of a dark nebula will be applied here several times. It may be considered as a modification of the preceding method and has hitherto, as far as I know, only been used by PANNEKOEK in his determination of the distance of the Taurus nebula. In the present paper *its application to the luminosity classes of the white stars will be very appropriate as the dispersion of the luminosity function within each class is small.*

Let us assume that there is an absorbing screen at the distance r_1 in the dark region absorbing ε magnitudes of the light of all stars at distances greater than r_1 . We introduce the logarithm of the distance through

$$\varrho = 5 \log r$$

and have

$$M = m + 5 - \varrho.$$

If a star situated behind this screen is observed to have the apparent magnitude m it has, in reality, the magnitude $m - \varepsilon$. The number of stars of magnitude m , $b_1(m)$, observed in the dark region is, consequently,

$$b_1(m) = \omega \int_0^{r_1} D(r) \varphi(M) r^2 dr + \omega \int_{r_1}^{\infty} D(r) \varphi(M - \varepsilon) r^2 dr, \quad (1)$$

where $D(r)$ is the density curve in a normal region and $\varphi(M)$ the luminosity function. Now we have the following expressions for the number of stars of magnitudes m and $m - \varepsilon$:

$$b(m) = \omega \int_0^{\infty} D(r) \varphi(M) r^2 dr,$$

$$b(m - \varepsilon) = \omega \int_0^{\infty} D(r) \varphi(M - \varepsilon) r^2 dr.$$

Putting

¹ PANNEKOEK, The distance of the dark nebulae in Taurus, Further remarks on the dark nebulae in Taurus, Proc. of the Kon. Ak. van Wet. te Amsterdam, 23, No. 5 (1920).

$$\gamma_1 = \frac{\int_0^{r_1} D(r) \varphi(M) r^2 dr}{\int_0^\infty D(r) \varphi(M) r^2 dr},$$

$$\gamma_2 = \frac{\int_0^{r_1} D(r) \varphi(M - \varepsilon) r^2 dr}{\int_0^\infty D(r) \varphi(M - \varepsilon) r^2 dr}, \quad (2)$$

equation (1) takes the form

$$b_1(m) = \gamma_1 b(m) + \gamma_2 b(m - \varepsilon). \quad (3)$$

Thus the number of stars of mag. m in the dark region becomes a sum of a proportion γ_1 of the stars of mag. m and a proportion γ_2 of the stars of mag. $m - \varepsilon$ in the normal region.

We shall now see how to compute γ_1 and γ_2 . We have to introduce analytical expressions for φ and D . The former function has the form of a normal error curve (equ. (1) of ch. IV). We then compute γ_1 and γ_2 for two different assumptions as to $D(r)$.

1) $D(r)$ has the form

$$D(r) = D_0 e^{-\frac{1}{2\alpha^2}(\varrho - \varrho_0)^2}. \quad (4)$$

If we introduce the expressions for $D(r)$ and $\varphi(M)$ into the numerator of γ_1 and remark that

$$dr = \frac{1}{5 \log e} 10^{0.2\varrho} d\varrho,$$

we find

$$\begin{aligned} \int_0^{r_1} D(r) \varphi(M) r^2 dr &= \frac{D_0}{5 \log e \cdot \sigma \sqrt{2\pi}} \int_{-\infty}^{\varrho_1} e^{-\frac{1}{2\alpha^2}(\varrho - \varrho_0)^2 - \frac{1}{2\sigma^2}(m - \varrho + 5 - M_0)^2 + \frac{0.6}{\log e} \varrho} d\varrho \\ &= C \cdot e^{f(m)} \int_{-\infty}^{\varrho_1} e^{-\frac{\alpha^2 + \sigma^2}{2\alpha^2\sigma^2} \left[\varrho - \frac{\sigma^2 \varrho_0 + (m - M_0 + 5)\alpha^2 + \frac{0.6}{\log e} \alpha^2 \sigma^2}{\alpha^2 + \sigma^2} \right]^2} d\varrho, \end{aligned}$$

where C is a constant and $f(m)$ a function which we need not know because it appears also in the denominator of γ_1 . Introducing now

$$x = \frac{(\alpha^2 + \sigma^2) \varrho - \sigma^2 \varrho_0 - \frac{0.6}{\log e} \alpha^2 \sigma^2 - \alpha^2 (m - M_0 + 5)}{\alpha \sigma \sqrt{2} (\alpha^2 + \sigma^2)}$$

we get

$$\int_0^{r_1} D(r) \varphi(M) r^2 dr = C_1 e^{f(m)} \int_{-\infty}^{x_1} e^{-x^2} dx.$$

For the denominator the same expression is obtained, only the limits of the integral are $-\infty$ and $+\infty$. The integral is thus $= \sqrt{\pi}$. — In quite an analogous manner the expressions in γ_2 are treated, and we finally get

$$\gamma_1 = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{x_1} e^{-x^2} dx; \quad \gamma_2 = \frac{1}{\sqrt{\pi}} \int_{x_2}^{\infty} e^{-x^2} dx, \quad (5)$$

where

$$\left. \begin{aligned} x_1 &= \frac{(\alpha^2 + \sigma^2) \varrho_1 - \sigma^2 \varrho_0 - \frac{0.6}{\log e} \alpha^2 \sigma^2 - \alpha^2 (m - M_0 + 5)}{\alpha \sigma \sqrt{2} (\alpha^2 + \sigma^2)} \\ x_2 &= \frac{(\alpha^2 + \sigma^2) \varrho_1 - \sigma^2 \varrho_0 - \frac{0.6}{\log e} \alpha^2 \sigma^2 - \alpha^2 (m - \varepsilon - M_0 + 5)}{\alpha \sigma \sqrt{2} (\alpha^2 + \sigma^2)} \end{aligned} \right\} \quad (6)$$

2) In the second case we assume

$$D(r) = D_0 r^{-s} = D_0 \cdot e^{-\frac{0.2s}{\log e} \varrho}. \quad (7)$$

In quite an analogous manner to that in the first case we arrive at the expressions for γ_1 and γ_2 , but in this case x_1 and x_2 are computed from the formulae

$$\left. \begin{aligned} x_1 &= \frac{1}{\sigma \sqrt{2}} \left[\varrho_1 + \frac{0.2 \sigma^2}{\log e} (s - 3) - (m - M_0 + 5) \right] \\ x_2 &= \frac{1}{\sigma \sqrt{2}} \left[\varrho_1 + \frac{0.2 \sigma^2}{\log e} (s - 3) - (m - \varepsilon - M_0 + 5) \right] \end{aligned} \right\} \quad (8)$$

Thus in both cases we have to compute the integrals (5). They involve the Gaussian error integral $\Phi(x)$, defined through the relation

$$\int_0^x e^{-t^2} dt = \frac{\sqrt{\pi}}{2} \Phi(x),$$

for we easily find

$$\left. \begin{aligned} \gamma_1 &= \frac{1}{2} \left[1 + \Phi(x_1) \right] & x_1 > 0 \\ \gamma_1 &= \frac{1}{2} \left[1 - \Phi(x_1) \right] & x_1 < 0 \\ \gamma_2 &= \frac{1}{2} \left[1 - \Phi(x_2) \right] & x_2 > 0 \\ \gamma_2 &= \frac{1}{2} \left[1 + \Phi(x_2) \right] & x_2 < 0 \end{aligned} \right\} \quad (9)$$

The values of Φ are tabulated¹ and from them we find the following small table for the computation of γ_1 and γ_2 :

x_1	-2.0	-1.0	-0.8	-0.6	-0.4	-0.2	0.0	+0.2	+0.4	+0.6	+0.8	+1.0	+2.0
x_2													
γ_1	0.00	0.08	0.13	0.20	0.29	0.39	0.50	0.61	0.71	0.80	0.87	0.92	1.00
γ_2	1.00	0.92	0.87	0.80	0.71	0.61	0.50	0.39	0.29	0.20	0.13	0.08	0.00

The determination of the distance ϱ_1 and the absorbing power ε of the dark nebula is performed in the following manner. The density curve of the unobscured region is represented by (4) or (7). From the observed density curves in the two regions an approximate value of ϱ_1 can be found. With this value x_1 and x_2 are computed according to (6) or (8). They are of the form

$$\left. \begin{aligned} x_1 &= k - hm \\ x_2 &= x_1 + h\varepsilon \end{aligned} \right\}$$

x_1 and x_2 are computed for different values of m , x_2 under different hypotheses as to ε . Then γ_1 and γ_2 are found from (5) or the equivalent expressions (9) with the help of Table (10). After having computed γ_1 and γ_2 $b_1(m)$ is found from (3) for different values of m . From these the space densities can be calculated and a direct comparison is obtained between the observed and computed density curves. Many approximations are not needed, for when the first computation has been performed it is easy to see in what direction the values of ϱ_1 and ε have to be changed, in order to get the best agreement with the observations. The method is very sensitive to changes in the values, and if sufficient observation material is available, and the spreading of the luminosity function is small, a good determination of the distance and absorption of the nebula is obtained.

¹ See e.g. CZUBER, Wahrscheinlichkeitsrechnung, I, p. 437 (3rd ed.).

3. It was mentioned above that some of the dark regions in the Milky Way are, perhaps, real vacancies among the stars. Such a void space must, evidently, have a similar influence upon the observed distribution of the stars as an absorbing nebula. In the present research we shall assume that the irregularities of the stellar distribution are caused by absorbing dark nebulae. This seems to be the most natural explanation, as the abundant existence of dark cosmic clouds must be considered as proved, owing to a great number of researches, part of which are referred to above. Furthermore the assumption of void spaces leads in many cases to very improbable consequences as to their extension in the line of sight.¹

I will briefly mention how the influence of a void space upon the distribution of the stars is calculated, although these formulae are not to be used here. If a void space extends from r' to r'' (or ϱ' to ϱ'') the number of stars of mag. m becomes

$$b_2(m) = b(m) - \omega \int_{r'}^{r''} D(r) \varphi(M) r^2 dr = b(m) \left[1 - \frac{\int_{r'}^{r''} D(r) \varphi(M) r^2 dr}{\int_0^\infty D(r) \varphi(M) r^2 dr} \right]$$

or

$$b_2(m) = b(m) \left[1 - \frac{1}{\sqrt{\pi}} \int_{x'}^{x''} e^{-x^2} dx \right].$$

Introducing as before the error integral we find

$$b_2(m) = b(m) \left[1 - \frac{\Phi(x'') \pm \Phi(x')}{2} \right],$$

where the $+$ sign is used when x' and x'' have different signs, the $-$ sign when they have the same sign.

x' and x'' are calculated from the following expressions:

1) If the density function has the form (4)

$$\left. \begin{aligned} x' &= \frac{(\alpha^2 + \sigma^2) \varrho' - \sigma^2 \varrho_0 - \frac{0.6}{\log e} \alpha^2 \sigma^2 - \alpha^2 (m - M_0 + 5)}{\alpha \sigma \sqrt{2} (\alpha^2 + \sigma^2)} \\ x'' &= \frac{(\alpha^2 + \sigma^2) \varrho'' - \sigma^2 \varrho_0 - \frac{0.6}{\log e} \alpha^2 \sigma^2 - \alpha^2 (m - M_0 + 5)}{\alpha \sigma \sqrt{2} (\alpha^2 + \sigma^2)} \end{aligned} \right\}$$

¹ PANNEKOEK, Loc. cit. (see note on p. 34).

2) If the density function has the form (7)

$$\left. \begin{aligned} x' &= \frac{1}{\sigma\sqrt{2}} \left[\varrho' + \frac{0.2\sigma^2}{\log e} (s-3) - (m - M_0 + 5) \right] \\ x'' &= \frac{1}{\sigma\sqrt{2}} \left[\varrho'' + \frac{0.2\sigma^2}{\log e} (s-3) - (m - M_0 + 5) \right] \end{aligned} \right\}$$

CHAPTER VI.

Investigation of the Different Galactic Regions.

In this chapter we are going to discuss the results of the computations of the density curves for the *B* and *A* stars in the four galactic regions. The most interesting conclusions to be drawn from these curves concern dark nebulae and their very striking influence upon the observed space distribution of the stars. The surface distribution of the stars will also be considered. Furthermore in the Cygnus and Cepheus regions the distribution of the stars in relation to the galactic plane will be discussed, as the plates of these two regions extend to somewhat higher galactic latitudes. — The material is considered as complete down to phot. mag. 10.5 inclusive (cf. the Tables 9, 15, 20, and 24).

A. The region in Cygnus (gal. long. about 43°).

1. The total area with measurable spectra covered by the six plates in the Cygnus region amounts to 126 square degrees. For the arrangement of the plates I refer to Fig. 2. The galactic plane (for the coordinates of the gal. pole see p. 12) divides the area into two nearly equal parts. The two central areas (denoted by N_1 and S_1) embrace a part of the great »Cygnus cloud» (N_1) and the poor region between γ and ε Cyg (S_1). The gal. latitudes of these areas are about $+2.5^\circ$ and -2.5° . The two outer areas N_2 and S_2 have a gal. latitude of about $+9^\circ$ and -9° and extend to $\pm 11^\circ$ gal. latitude.

The distribution of the stars of different luminosity classes over intervals of apparent photographic magnitude is given in Table 9. The surface densities (number of stars per sq. degree) are also given for the total number within each class having $m \leq 10.5$. I think the most interesting fact brought to light by this table is the very strong concentration in region N_1 of the absolutely bright stars of the τ groups¹: the area densities are 4–7 times as great in N_1 as in S_1 . In the regions N_2 and S_2 the number of stars

¹ For the sake of abbreviation I often use, in chapters VI and VII the designation » τ groups» to design stars belonging to classes τ and $\tau-$. In the same manner » σ » may mean $\sigma+$, σ , $\sigma-$; » ρ » is used for ρ , μ ; and » κ » for $\kappa-$ and κ stars.

Table

Number of stars and area

m	Reg. $N_1 : 24.8 \square^\circ$					Reg. $S_1 : 28.8 \square^\circ$				
	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$
10.6—11.0	8	6	22	24	5	2	14	17	27	5
10.1—10.5	20	25	37	44	29	7	10	25	40	28
9.6—10.0	16	18	20	23	19	1	5	13	19	19
9.1— 9.5	10	13	18	16	18	4	3	13	23	13
8.6— 9.0	15	10	22	10	4	1	1	16	9	10
8.1— 8.5	9	4	9	6	4	0	0	19	3	1
7.6— 8.0	9	5	6	2	1	2	1	8	3	0
7.1— 7.5	8	2	5	0	3	0	1	3	0	0
6.6— 7.0	2	0	2	0	0	0	0	2	0	1
6.1— 6.5	0	4	4	0	0	0	1	1	0	0
≤ 6.0	2	4	1	2	0	1	0	0	0	1
Total numb. ≤ 10.5	91	85	124	103	78	16	22	100	97	73
Area dens. stars ≤ 10.5	3.67	3.43	5.00	4.15	3.15	0.56	0.76	3.47	3.37	2.54

Total number of

belonging to these groups, and the area densities are, it is true, still smaller, but this, certainly, is due to the higher gal. latitude of these regions. The small number of stars in reg. S_1 is, on the contrary, explained by the assumption of an absorbing nebula as will be shown later. — The number of stars of the other luminosity groups is also greatest in reg. N_1 although the difference in area density between N_1 and S_1 is rather small as compared with the difference for the τ groups. The small area densities for the outer regions depend on the effect of galactic concentration.

After this general survey of the surface distribution of the stars within the Cygnus region we are now going to examine the density curves in the four parts of the region.

2. *The star-rich region N_1 , and the poor region S_1 .* The main difference between the two regions N_1 and S_1 is to be expected in the space distribution of the absolutely] bright stars. In Table 10 I give the space densities for the τ groups computed according to the method described above. The numbers designate, as always, $D_{\text{abs.}}$ = number of stars/1000 cubic parsecs. The density curves corresponding to the numbers of Table 10 are given in Fig. 3, full-drawn curves. The signification of the dotted curves will be explained later.

Before proceeding further I will make some general remarks here concerning the calculated densities for the τ groups for small distances. The

9.

densities in the Cygnus region.

Reg. $N_2 : 38.1 \square^\circ$					Reg. $S_2 : 34.7 \square^\circ$				
τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$
0	3	6	13	10	1	6	19	18	5
0	1	25	36	17	1	2	28	29	21
1	4	17	12	23	0	1	10	10	11
1	4	13	14	17	2	4	12	4	7
1	2	12	7	8	1	2	13	4	0
0	2	9	3	4	1	0	6	1	6
1	2	7	1	5	0	1	12	3	3
2	3	3	4	0	1	1	5	0	1
0	1	2	0	1	0	0	1	0	0
0	0	3	0	1	1	2	1	0	1
1	1	2	0	0	0	0	0	0	0
7	20	93	77	76	7	13	88	51	50
0.18	0.52	2.44	2.02	2.00	0.20	0.37	2.54	1.47	1.44

stars with $m \leq 10.5 = 1271$.

number of τ and $\tau-$ stars at distances below 1000 parsecs is often rather small, especially the number of τ stars. Therefore the densities may be uncertain. Besides, let us assume that there are some super-giants among the brightest τ stars having an absolute magnitude of -5 or even -6 . Then such stars are placed at too small a distance by assuming an absolute magnitude of only about -3 . The computed densities would, consequently, become too large, and the rapid increase of the densities for small distances would, in reality, be reduced. On the other hand, according to CHARLIER, the cluster of bright B stars extends in the direction of Cygnus to about 800 parsecs. From this point of view the strong increase of the densities for distances below 1000 parsecs is quite natural. In ch. VII, § 2, we shall return to this comparison with CHARLIER.

Let us first examine the curves for the region N_1 and see what conclusions may be drawn from them. It may be assumed that the irregular run of the density curve for the τ stars at about 1000 parsecs is caused by an agglomeration of stars forming the »Cygnus cloud». But as seen from Table 10 the number of bright stars is very small. And, as regards the $\tau-$ stars, they do not show any influence of such a star-cloud. It can be stated, however, from the study of these stars that the »star-cloud» is not situated at distances between 1500 and 4 à 5000 parsecs. If there is a real agglomera-

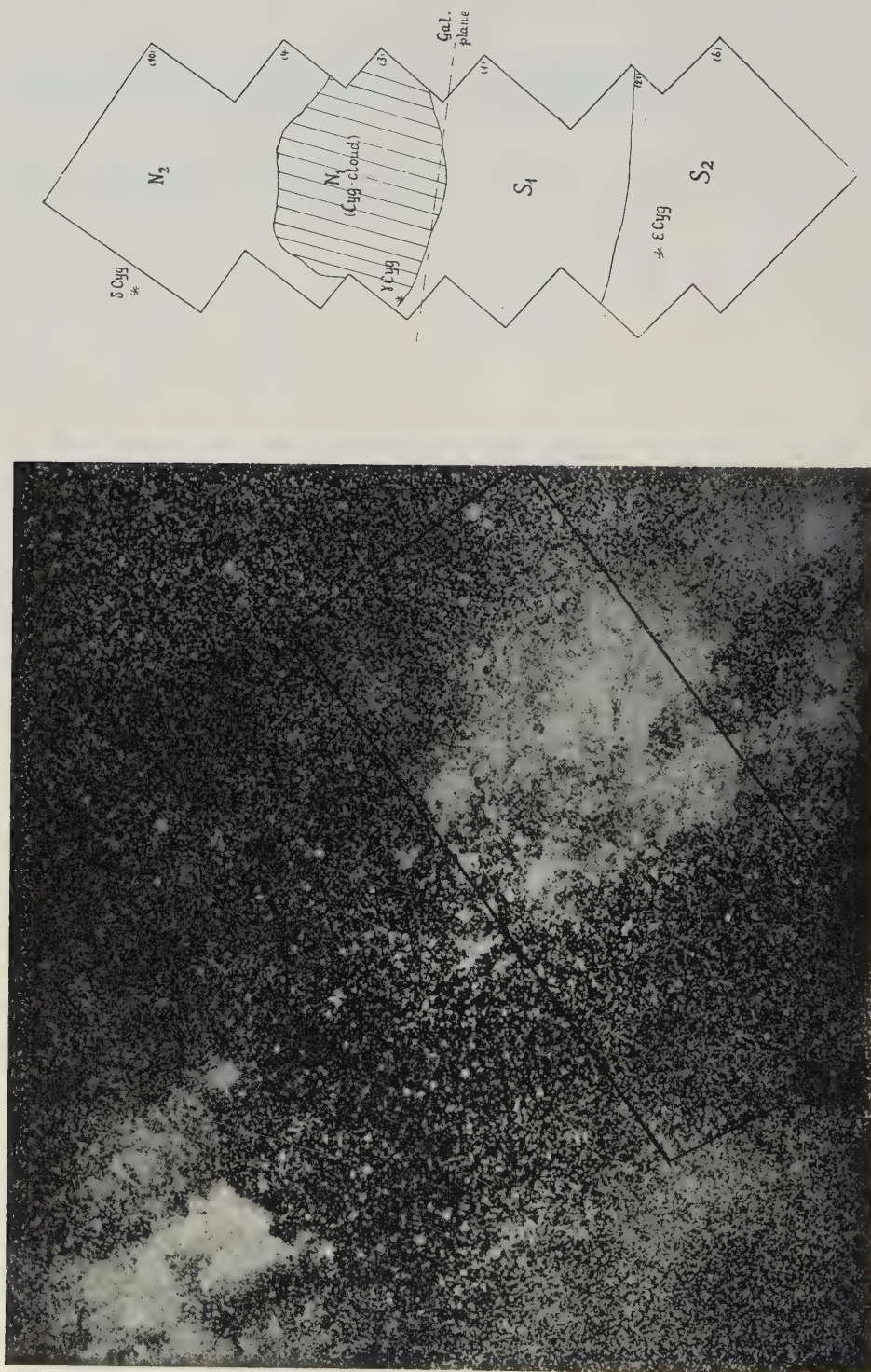


Fig. 2. The Cygnus region. To the right: the subdivision into smaller areas. To the left: a photograph by WOLF (from »Die Milchstrasse») showing the areas N_1 , S_1 , and part of N_2 .

Table 10.

Space density for the τ and $\tau-$ stars in the regions N_1 and S_1 .

τ, N_1			τ, S_1					$\tau-, N_1$			$\tau-, S_1$			
r	n	$D_{\text{abs.}}$	r	$n_{\text{obs.}}$	$D_{\text{abs.}}$ (obs.)	$n_{\text{comp.}}$	$D_{\text{abs.}}$ (comp.)	r	n	$D_{\text{abs.}}$	$n_{\text{obs.}}$	$D_{\text{abs.}}$ (obs.)	$n_{\text{comp.}}$	$D_{\text{abs.}}$ (comp.)
410	0.5	0.004						196	1	0.075				
516	1	.004	541	0.5	0.002	(0.5)	(0.002)	247	1.5	.060				
650	0.5	.001	681	0.5	.001	(0.5)	(.001)	311	1.5	.030				
818	0.5	.0005	857	0	.000	0	.000	392	2	.019	0.5	0.004	1	0.008
1030	3	.00159	1078	0	.000	0	.000	493	1.5	.007	0.5	.002	1	.004
1296	5	.00182	1358	0	.000	0	.000	621	2	.005	0.5	.001	1	.002
1633	7	.00093	1709	1	.00010	0.5	.00005	782	3.5	.00423	1	.00104	1	.00104
2055	9	.00062	2152	1.5	.00007	0.5	.00003	984	5.5	.00332	0.5	.00026	0.5	.00026
2587	11	.00036	2709	1	.00003	0.5	.00002	1238	7.5	.00226	1	.00026	1	.00026
3257	12	.00021	3411	2	.00002	3	.00004	1559	11	.00166	2	.00026	2.5	.00032
4100	14	.00012	4294	2.5	.00001	5	0.00003	1963	18	.00139	4.5	.00029	4.5	.00029
5163	19	0.00008	5406	3	0.00001			2471	25	0.00094	9	0.00029	7.5	0.00024

tion of stars within this distance with relatively small extension in the line of sight *it is probably to be located at a distance of about 1000—1200 parsecs.*

This very star-rich region has been studied by many astronomers who have tried to determine the distance of the star-cloud. The results are extremely diverging. PANNEKOEK from star-counts derived a distance of 40000 parsecs¹, later on reduced to 18000 parsecs.² He considers that there is an agglomeration of bright stars at 200—600 parsecs, while the Cygnus cloud should be built up of very faint stars. But EASTON³ gives a comparison between the area distribution of *BD*-stars of magnitudes 8.1—9.5 and the Milky Way's structure; he finds a very strong correlation from which he concludes that the agglomeration of bright stars and the Cygnus cloud belong to each other. — Other determinations of the distance of the Cygnus cloud are those of LUNDMARK⁴ who from star-counts derived a distance of 6700 parsecs, and KOPFF⁵ who found 4000—6000 parsecs under the assumption that the general spectral character of the cloud corresponds to type *A—F*, and putting $M=0$

¹ PANNEKOEK, The distance of the Milky Way, Month. Not., 79, 500 (1919).

² PANNEKOEK, The distance of the galaxy in Cygnus, Bull. of the Ast. Inst. of the Netherlands, No. 11 (1922).

³ EASTON, Correlation of the distribution of bright stars and galactic light in Cygnus, Ibid., No. 27 (1922).

⁴ LUNDMARK, The relations of the globular clusters and spiral nebulae to the stellar system p. 78, K. Svenska Vet.sk. ak.:s Handl., Band 60, No. 8 (1920).

⁵ KOPFF, Über Häufigkeitsfunktion und Entfernung bei den hellen Milchstrassenwolken, Astr. Nachr., No. 5177 (1922).

or $+1$, a determination undoubtedly rather uncertain. — O. STRUVE from a research on the surface distribution of O and B stars draws the conclusion that the bright and faint stars belong to the same group.¹ I will make some remarks here on the investigation of STRUVE as far as it concerns the Cygnus region.

STRUVE'S material consists partly of stars contained in the Draper Catalogue (the mean apparent phot. mag. of which is $= 7.2$), partly of fainter stars from the Henry Draper Extension (mean app. phot. mag. $= 9.4$). From the former stars he gets under the assumption $M = -2.2$ a distance $= 780$ parsecs, but in order to get the same distance from the faint stars he must assume $M = 0.0$ for these stars. It is possible that the absolute magnitude really changes with the apparent magnitude, but such a great change can hardly be assumed. It was pointed out by CHARLIER in his latest research on the B stars that the values of R where $M = -5 \log R$, decrease with increasing apparent magnitude. The range in R is 0.8 (in the mean for the groups $B0-B5$) for a range from < 6.0 to > 8.0 in apparent magnitude, corresponding to an increase in the numerical value of M with about 0.3 mag. — Returning to the stars used by STRUVE in determining the distance of the Cygnus cloud we find that among those contained in the Draper Catalogue 23 are τ and 7 τ -stars while of the faint stars of the H.D.Ext. 19 are τ and 19 τ -stars. The mean absolute magnitude for all the bright stars becomes -2.9 for the faint -2.5 , thus a slight increase in M from apparently bright to faint stars. The distances derived do not agree, it is true, but I do not think it can be considered as proved from the surface distribution only that all these stars are really situated at the same distance, forming a star-cloud.

The determinations of the distance of an eventual star-cloud vary, evidently, considerably. It is worth noting that for a star-cloud in Aquila PETERSSON found a distance of 1500 parsecs² the author 1000 parsecs³, a distance of the same order of magnitude as that proposed by me for the Cygnus cloud. Judging from the density curves for these stars, however, I should prefer to regard the Cygnus agglomeration more as a very star-rich region than as a real star-cloud with little extension in the radial direction. This might explain the uncertainty of the distance determinations.

The limit between the two regions N_1 and S_1 is very sharply defined. As is pointed out by O. STRUVE this depends on the dark nebulosities situated in reg. S_1 and evidently connected with the dark regions near the North America nebula (see the WOLF photograph reproduced in Fig. 2). The density curves for this dark region S_1 for the τ groups are also given in Fig. 3, founded upon the numbers of Table 10. The effect of the absorbing nebula

¹ O. STRUVE, Über die Verteilung der heisseren Helium-Sterne in Beziehung auf die Struktur der Milchstrasse, Astr. Nachr., No. 5522 (1927).

² PETERSSON, Effective Wave-lengths etc., p. 19, Arkiv för matem., astr. & fys., 19 A, No. 3 (1925).

³ SCHALÉN, Spectral classification of faint Milky Way stars in Aquila, Arkiv för matem., astr. & fys., 18 No. 36 (1925).

is evident in both groups. We are going to determine the distance of that nebula applying the formulae of ch. V.

For this purpose the density curve of reg. N_1 is assumed to represent the normal distribution of stars, from which we have to start. Region N_1 is situated at the same north galactic latitude as S_1 at south; thus there is no effect of galactic latitude when comparing N_1 and S_1 . — It is seen from the figure and the table that for distances below, say, 800 parsecs the curves

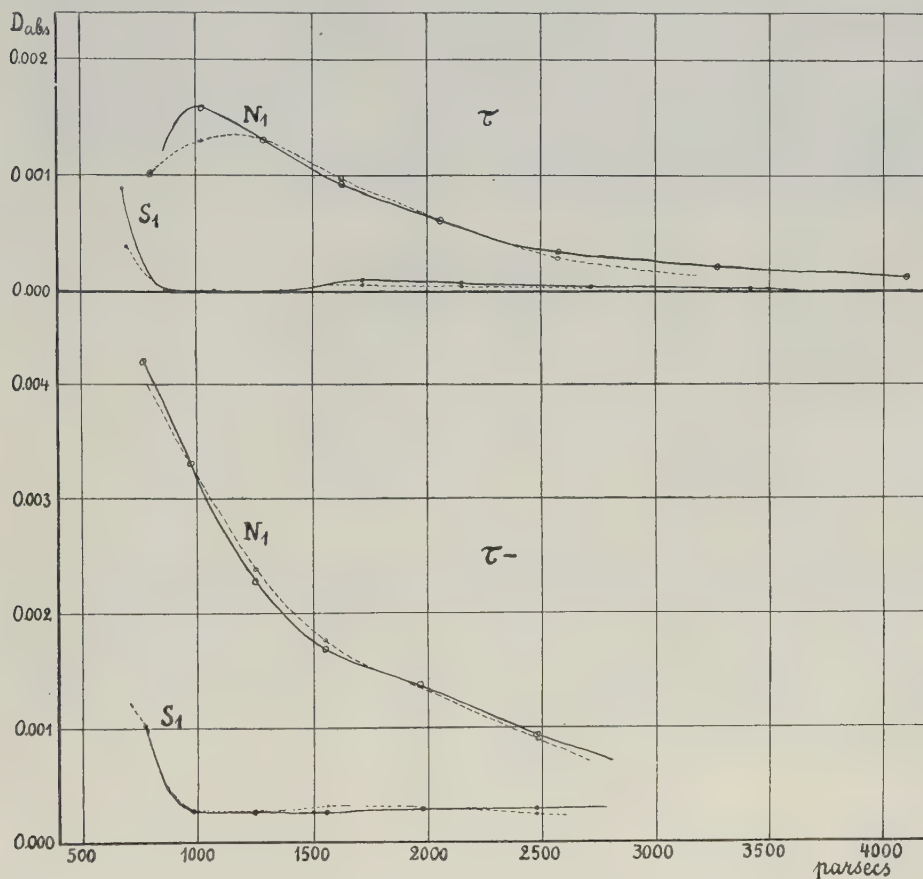


Fig. 3. Density curves for the τ groups in the regions N_1 and S_1 of Cygnus (dotted curves: the assumed curves of N_1 and computed of S_1).

show the same rapid increase in both regions. Thus for small distances the curves do not interest us specially.

We apply the formulae to the τ stars and $\tau-$ stars separately.

a) The τ stars. Let us represent the density curve of region N_1 by the formula

$$D(r) = 0.00135 e^{-\frac{1}{2}(\varrho - 15.5)^2}$$

which is the dotted curve in the figure. It accords very well with the observed curve within the whole distance interval except for small dis-

tances. In our formulae (6) (ch. V) the constants then have the following values:

$$\begin{aligned} \varrho_0 &= 15.3, & \alpha^2 &= 1, \\ M_0 &= -3.3, & \sigma &= 0.7, \end{aligned}$$

with which we find

$$\begin{aligned} x_1 &= 1.23 \varrho_1 - 0.83 m & - 13.64 \\ x_2 &= 1.23 \varrho_1 - 0.83 (m - \varepsilon) & - 13.64. \end{aligned}$$

The observed star-numbers and density curve of the dark region are best represented by taking

$$\varrho_1 = 14.5, \quad \varepsilon = 2.5,$$

thus

$$r_1 = 800 \text{ parsecs.}$$

γ_1 and γ_2 have then the following values for different m :

$m =$	6	7	8	9	10
$\gamma_1 =$	0.13	0.00	0.00	0.00	0.00
$\gamma_2 =$	0.05	0.26	0.68	0.95	1.00

Then we obtain the dotted curve of Fig. 3. The computed star-numbers and densities are also given in Table 10. — If instead of the above density curve we assume a curve of the form $D = 6.8 r^{-1.2}$ we get the same value of ε and a value for ϱ_1 situated between 14.5 and 15.0. We may thus say that the value for the distance obtained from the τ stars is at the least 800 parsecs.

b) The τ - stars. The τ - curve in region N_1 is represented by

$$D(r) = 25.4 r^{-1.3}$$

as is seen from Fig. 3 (the dotted curve). In our formulae we have to put

$$\begin{aligned} s &= 1.3, \\ M_0 &= -1.7, & \sigma &= 0.5, \end{aligned}$$

and get

$$\begin{aligned} x_1 &= 1.41 \varrho_1 - 1.41 m & - 9.75 \\ x_2 &= 1.41 \varrho_1 - 1.41 (m - \varepsilon) & - 9.75, \end{aligned}$$

from which we find the following values:

$$\begin{aligned} \varrho_1 &= 14.2, & \varepsilon &= 1.5, \\ r_1 &= 700 \text{ parsecs.} \end{aligned}$$

They give for different m the values

$m =$	6	7	8	9	10
$\gamma_1 =$	0.98	0.71	0.08	0.00	0.00
$\gamma_2 =$	0.00	0.00	0.07	0.66	0.98

The representation of the observed curve in S_1 (see Fig. 3, the dotted curve) is very good.

The two values obtained from the τ and $\tau-$ stars separately are thus in good agreement and indicate that *the absorbing nebula is situated at a distance of about 800 parsecs absorbing about 2 magnitudes of the star-light.*

From the numbers $B(m)$ only it would be rather difficult to draw any conclusions as to the difference in space distribution between N_1 and S_1 . From Table 9 we easily find the following numbers $\log B(m)$ reduced to the area of reg. N_1 :

Star-numbers $\log B(m)$.

m	τ			$\tau-$		
	N_1	S_1	$\Delta \log B(m)$	N_1	S_1	$\Delta \log B(m)$
10.5	1.96	1.14	+0.82	1.93	1.27	+0.66
9.5	1.74	0.84	+0.90	1.62	0.78	+0.84
8.5	1.48	0.41	+1.07	1.28	0.41	+0.87
7.5	1.08	-0.07	+1.15	1.00	0.23	+0.77
6.5	0.30	-0.07	+0.37	0.90	-0.07	+0.97

For the group $\tau-$ the differences $\Delta \log B(m)$ are very constant. For τ there is a discontinuity in the differences between $m = 6.5$ and $m = 7.5$. This would correspond to a distance of the absorbing medium of about 1000 parsecs taking $M = -3.3$. The displacement along the axis of m of the curves given by the numbers $\log B(m)$ is about 2.5 magnitudes.

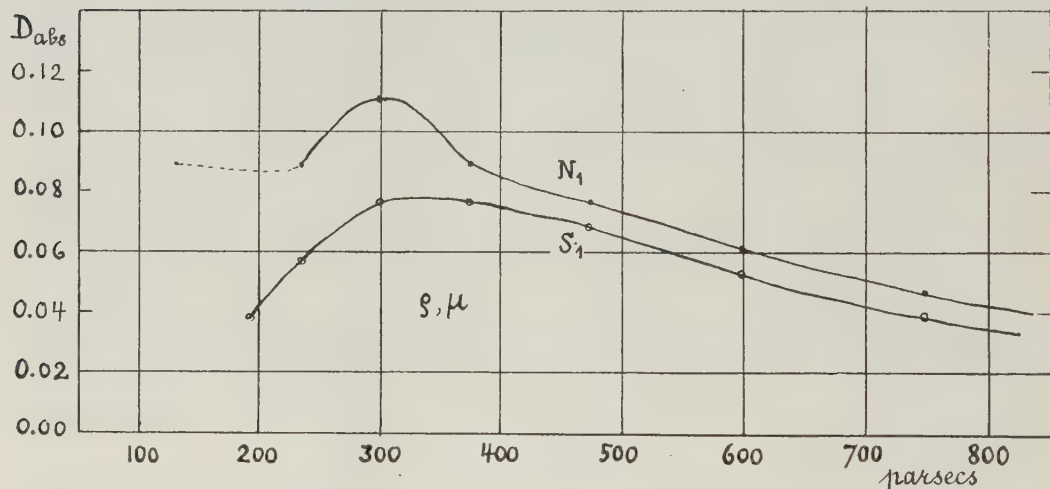
We now pass to the other luminosity classes. According to Table 9 the difference in area density between N_1 and S_1 for these groups is not very marked. In Table 11 the computed space densities are given for both regions. For these stars I do not give the number of stars for each interval of distance. A comparison with the star-numbers of Table 9 may give an idea of the reliability of the densities for different distances. — In Fig. 4 the density curves for the ϱ, μ stars are given.

It is obvious that *the distribution in space of the stars of lower luminosity is nearly identical for the two regions N_1 and S_1 .* The densities are generally a little larger in N_1 than in S_1 but the general run of the curves is the same. No effect of obscuring matter in S_1 is perceptible until within distances of about 800 parsecs. But for greater distances we see that within the σ group the densities decrease considerably quicker in S_1 than in N_1 which confirms our result as to the distance of the dark nebula.

Table 11.

Space density for the σ , ϱ , and κ groups in N_1 and S_1 .

r	$\sigma+-\sigma-$		$\varrho-\mu$		$\kappa-, \kappa$	
	N_1	S_1	N_1	S_1	N_1	S_1
200					0.40	0.26
300	(0.10)	(0.12)	0.108	0.077	.81	.26
400	.073	.080	.084	.073	.21	.18
500	.052	.060	.072	.065	0.18	0.13
600	.039	.040	.061	.054		
700	.029	.026	.051	.042		
800	.023	.015	.043	.036		
900	.019	.012	0.041	0.033		
1000	0.016	0.009				

Fig. 4. Density curves for stars of type ϱ, μ in the regions N_1 and S_1 of Cygnus.

As was mentioned above PANNEKOEK¹ has found that there is an agglomeration of bright stars in Cygnus at distances between 200 and 600 parsecs. In my curves this agglomeration is visible only in the ϱ group. The nearly identical run of the curves is in agreement with PANNEKOEK's statement that »the number of stars in the faint region to the east of the cloud is hardly smaller than in the bright patch down to the twelfth mag., and yields nearly identical results for the agglomeration at 400 parsecs».

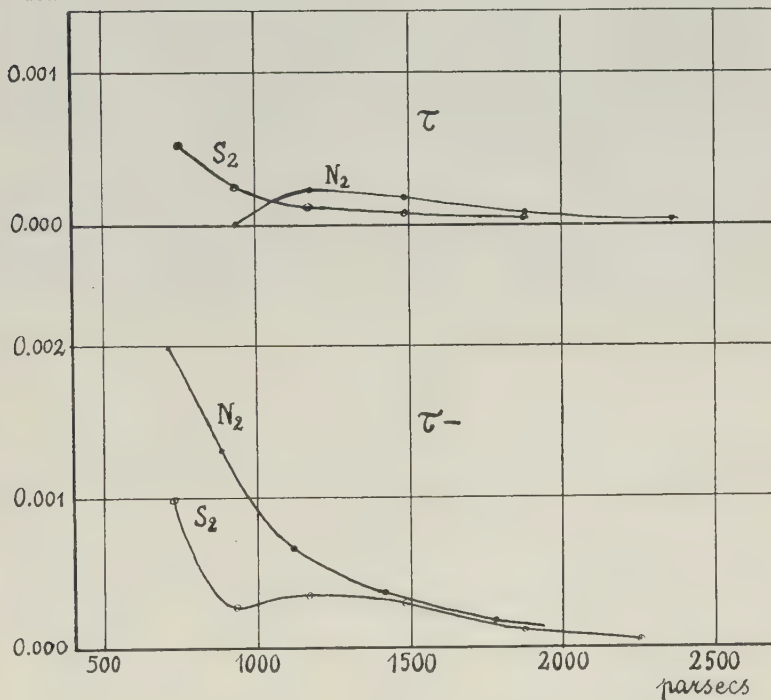
3. *The two areas in Cygnus at higher galactic latitudes.* As the white stars have a strong concentration to the galactic plane a decrease in star-

¹ PANNEKOEK, The distance of the galaxy in Cygnus, Bull. of the Ast. Inst. of the Netherlands, No. 11 (1922).

Table 12.

Space density for the τ and $\tau-$ stars in the regions N_2 and S_2 .

r	τ, N_2	τ, S_2	r	$\tau-, N_2$	r	$\tau-, S_2$
471	0.002		179	(0.033)		
593	.001		225	(.016)		
746	.000	0.001	283	.000		
940	.000	.00025	357	.000	374	0.008
1182	.00023	.00012	450	.004	471	.004
1489	.00017	.00006	566	.003	593	.001
1875	.00003	.00003	713	.002	746	.001
2359	.00001	.00003	897	.00128	940	.00025
2975	.00001	.00002	1130	.00064	1182	.00036
3740	0.00001	0.00001	1422	.00037	1489	.00031
			1790	0.00018	1875	.00013
					2359	0.00008

 $D_{\text{abs.}}$ Fig. 5. Density curves for the τ groups in the regions N_2 and S_2 of Cygnus.

density might be expected already at the galactic latitude of the regions N_2 and S_2 . I have mentioned that the surface density (Table 9) is smaller than in the other two regions.

The τ groups. The number of τ stars is extremely small in both regions. In Table 12 the space densities for these stars as well as for the $\tau-$ stars are given. The densities are very small as compared with those of region N_1 . The curves are given in Fig. 5. I do not think that the small densities obtained for these regions can be caused by obscuring matter at great distances. It is found from a closer comparison of Figs. 5 and 3 that the curves of Fig. 5 are more like those of reg. N_1 than those of S_1 . A study of the star-numbers of Table 9 gives the following small table for the differences $\mathcal{A} \log B(m)$ between the different regions (reduced to the area of N_1):

Differences $\mathcal{A} \log B(m)$.

m	τ		$\tau-$	
	N_1-N_2	N_1-S_2	N_1-N_2	N_1-S_2
10.5	+1.30	+1.26	+0.82	+0.97
9.5	+1.15	+1.11	+0.63	+0.77
8.5	+1.07	+1.15	+0.52	+0.88
7.5	+0.79	+0.93	+0.49	+0.67
6.5	+0.49	+0.45	+1.09	+0.75

These numbers show no marked discontinuity. Therefore I think we may conclude that *the small densities of regions N_2 and S_2 are caused by the higher galactic latitude of these two regions.*

The σ , ϱ , and $\varkappa$ groups. The space densities for these groups in regions N_2 and S_2 are given in Table 13. As they show nothing of special interest the curves are not drawn here. It may be remarked that the densities within the ϱ and $\varkappa$ groups are considerably smaller for the south area than for the north one.

Table 13.

Space density for the σ , ϱ , and $\varkappa$ groups in N_2 and S_2 .

r	$\sigma + -\sigma -$		$\varrho - \mu$		$\varkappa -, \varkappa$	
	N_2	S_2	N_2	S_2	N_2	S_2
200	0.121	(0.100)	0.090	0.048	0.29	0.15
300	.056	.090	.036	.041	.24	.08
400	.041	.050	.039	.020	0.15	0.06
500	.030	.030	.032	.013		
600	.022	.020	.027	.013		
700	.017	.014	.024	(0.014)		
800	0.014	0.009	0.022			

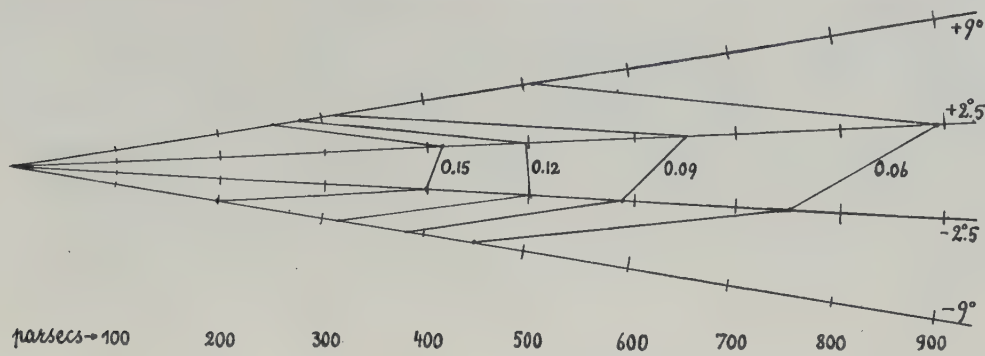


Fig. 6. Equi-density lines in Cygnus for stars of types $\sigma + -\mu$ ($B8-A0$).

4. *Discussion with regard to galactic latitude.* The curves of equal density for the τ groups will not be drawn as these curves would be strongly influenced by the obscuring nebula of reg. S_1 . The rapid thinning out of these stars when leaving the galactic plane was just pointed out: an effect of the strong galactic concentration of the B stars.

The dark nebula has no influence upon the distribution of the stars for smaller distances. It is therefore interesting to study the density as a function of galactic latitude for the stars of lower luminosity. A glance at Tables 11 and 13 shows that for a given distance the density is much greater for the two areas near the galactic plane than for the other two.

In Fig. 6 the equi-density lines for the stars of types $\sigma + -\mu$ are given; these types embrace mainly $B8-A0$ stars (according to Table 2). Fig. 6 is based on the numbers of Table 14. First the distances are given at which equal density is attained and after that the corresponding heights over the galactic plane through the point of observation calculated from $H = r \sin b$, where b is the galactic latitude. On account of the low galactic latitude of all the regions considered here the heights are rather small. Fig. 6 yields a

Table 14.

Density at different distances and heights over the galactic plane for the $B8-A0$ stars (Cygnus).

Area $D_{\text{abs.}}$	Distances (parsecs)				Heights (parsecs)			
	N_2	N_1	S_1	S_2	N_2	N_1	S_1	S_2
0.15	250	410	400	200	39	18	17	31
.12	275	495	500	315	43	22	22	49
.09	310	650	590	380	48	28	26	59
.06	505	900	750	440	79	39	33	69
0.03	> 800			(800)	> 125			> 125

good illustration of the arrangement of the A stars near the galactic plane in this direction of the Milky Way. The same density is reached at a much smaller distance in the regions at 9° gal. latitude than in those at 2.5° . But the lines are not parallel to the galactic plane, for in such a case the heights in each horizontal line of Table 14 would be equal for the northern side and the southern one, respectively. — The π groups are not combined with the others for their density curve is determined only for a small interval of distance; furthermore the densities are, in general, considerably greater than those for the σ and ϱ classes and would consequently be too dominating in the results. — In the following chapter a more extensive investigation on the density lines will be performed.

B. The region in Cepheus (gal. long. about 70°).¹

1. In this region five plates were exposed covering an area of about 114 square degrees. For the arrangement of the plates see Fig. 7. With the galactic coordinate system used in this research the area investigated extends from $+7^\circ$ to -12° galactic latitude. The structure of the Milky Way is very variable in this area as it contains a very bright region, and near that a darker region with very black rifts.

In treating the material statistically I have distinguished first between three greater parts. *Part N* lies to the *north* of the galactic plane from δ and ϵ Cep to north of μ Cep. *Part S* is situated to the *south* of the galactic plane and contains the very bright star-cloud. The galactic latitude of these regions is about $+3^\circ$ and -3° . Finally, the third part S_1 is situated at about -10° galactic latitude. — But each of the two first-mentioned areas was divided into two smaller, according to the galactic structure (see the photograph, Fig. 7). Thus *region Nb* embraces the *bright* parts of *N*, while *region Nd* consists of the very *dark* patches running out from a dark oval-shaped spot near δ Cep. In the same manner *Sb* is the *brightest* part of *region S* and *Sd* the *dark* region at somewhat higher southern galactic latitude.

The number of stars of different sub-classes and intervals of photographic magnitude, and the area densities are given in Table 15 for the different parts of the Cepheus region. The difference between the two parts of *reg. N* lies evidently in the number of stars of the τ groups: the surface densities are about 2.5 times as large in *Nb* as in *Nd* while for the other groups practically no difference exists. The surface densities for the τ groups in *Nb* are most comparable with those of *Sb* although the latter densities are larger. A remarkable fact in *reg. Sb* is the very large number of faint stars, especially in the τ groups. In *reg. Sd* the τ stars are extremely rare. For the region S_1 the area densities of the τ groups are small as the galactic latitude of this region is higher. Also for the other luminosity groups the densities are smaller than in *reg. S*.

¹ Although this region extends also to the constellation Lacerta, I will call it here, for the sake of brevity, the Cepheus region.

Table

Number of stars and area

<i>m</i>	Reg. <i>Nb</i> : 19.6 □°					Reg. <i>Nd</i> : 19.6 □°				
	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$
10.6—11.0	4	11	23	12	3	2	2	18	12	3
10.1—10.5	7	23	23	8	8	9	14	19	8	10
9.6—10.0	5	12	8	1	13	2	4	15	4	6
9.1— 9.5	3	8	10	3	6	4	1	7	2	6
8.6— 9.0	4	5	6	2	4	2	0	3	2	2
8.1— 8.5	7	2	2	1	5	0	3	4	3	3
7.6— 8.0	4	1	4	0	1	0	0	3	0	2
7.1— 7.5	5	0	0	1	3	0	2	1	0	0
6.6— 7.0	3	0	2	0	0	0	0	1	3	1
6.1— 6.5	1	0	1	0	0	1	0	2	0	0
≤ 6.0	6	1	0	0	0	1	1	0	0	0
Total numb. ≤ 10.5	45	52	56	16	40	19	25	55	22	30
Area dens. stars ≤ 10.5	2.80	2.65	2.86	0.82	2.04	0.97	1.28	2.81	1.12	1.53

Total number of

We are now going to discuss the space distribution of the stars in Cepheus, treating successively the regions *N*, *S*, and *S*₁, after which the results from the different regions will be compared.

2. *Region N, at gal. lat. about +3°.* A comparison of the space densities in the bright and dark parts of this region north of the galactic plane is of great interest. As was to be expected from Table 15 the main difference in the space distribution occurs within the τ groups. For the other groups the densities are found to be practically the same for the two parts. The space densities are given in Table 16 a and b.

Let us first consider the τ groups. Their density curves are given in Fig. 8. From our study of the dark nebula in the Cygnus region we may by the inspection of Fig. 8, at once conclude that a similar effect of absorbing matter appears in region *Nd*. I will try to deduce here the distance of this nebula, from a comparison between the two parts of reg. *N*. For this purpose I will assume that the density curve of region *Nb* represents the normal distribution. The two areas are situated at practically the same gal. latitude. The two τ groups are treated separately:

15.

densities in the Cepheus region.

Reg. Sb : 19.3 □°					Reg. Sd : 19.3 □°					Reg. S ₁ : 36.1 □°				
τ	τ−	σ+−σ−	ρ−μ	κ−,κ	τ	τ−	σ+−σ−	ρ−μ	κ−,κ	τ	τ−	σ+−σ−	ρ−μ	κ−,κ
7	16	21	21	2	1	2	15	20	7	1	3	18	33	9
20	32	62	21	13	3	11	31	17	13	3	4	38	24	18
14	18	33	7	7	1	9	22	7	5	1	2	27	10	10
5	7	18	7	12	5	3	21	10	3	2	7	21	12	5
5	5	17	5	5	0	3	14	3	1	0	8	17	4	2
0	7	11	3	2	1	2	6	1	2	0	8	5	1	3
3	2	1	1	0	0	1	7	0	1	2	3	5	1	3
2	1	3	2	0	0	0	1	1	1	3	0	0	0	0
1	2	0	1	0	0	0	0	0	0	0	2	0	1	0
0	0	1	0	0	0	0	0	1	0	2	1	0	1	0
0	0	0	0	0	0	1	0	0	1	1	0	0	0	0
50	74	146	47	39	10	30	102	40	27	14	35	113	54	41
2.59	3.83	7.56	2.44	2.02	0.52	1.55	5.28	2.07	1.40	0.39	0.97	3.13	1.50	1.14

stars with $m \leq 10.5 = 1182$.

a) The τ stars. The curve of reg. Nb may, except for small distances, be represented by

$$D(r) = 0.00117 e^{-\frac{1}{1.4} (q-15.4)^2},$$

the dotted curve in Fig. 8. We have then the following constants:

$\varrho_0 = 15.4,$ $\alpha^2 = 0.7,$

$M_0 = -3.3,$ $\sigma = 0.7,$

which give, according to the formulae of ch. V:

$x_1 = 1.32 \varrho_1 - 0.78 m$ -15.32

$x_2 = 1.32 \varrho_1 - 0.78 (m - \varepsilon) - 15.32.$

A rather good approximation to the observed curve is obtained by

$\varrho_1 = 15.3,$ $\varepsilon = 2.0,$

$r_1 = 1150 \text{ parsecs.}$

Table 16.

Space density in the region N of Cepheus.

a)

r	τ, Nb		τ, Nd				r	$\tau-, Nb$		$\tau-, Nd$			
	n	$D_{\text{abs.}}$	$n_{\text{obs.}}$	$D_{\text{abs.}}$ (obs.)	$n_{\text{comp.}}$	$D_{\text{abs.}}$ (comp.)		n	$D_{\text{abs.}}$	$n_{\text{obs.}}$	$D_{\text{abs.}}$ (obs.)	$n_{\text{comp.}}$	$D_{\text{abs.}}$ (comp.)
340	1	0.019											
430	2	.019											
541	2	.009	0.5	(0.002)									
681	1	.002	0.5	(.001)	1	(0.007)	650			1	0.003		
857	1	.001	0.5	(.001)	1	(.001)	818	0.5	0.001	1.5	.002	0.5	0.001
1078	2	.00116	0.5	(.0003)	0.5	(.0004)	1030	2	.00133	1	.00066	1	.00066
1358	4	.00116	0	.000	1	.00026	1296	4.5	.00149	1	.00033	1	.00033
1709	5	.00072	0	.000	0.5	.00009	1633	7	.00117	2	.00033	2	.00033
2152	5.5	.00039	0	.000	0.5	.00003	2055	11	.00092	3.5	.00029	3.5	.00029
2719	5	.00019	2	.00007	2	.00008	2587	18	.00075	8.5	0.00037	6	0.00026
3411	4.5	.00008	2.5	.00005	3.5	.00006	3257	(32)	0.00067				
4294	(4)	0.00003	5	.00005	3.5	.00003							
5406			6.5	0.00003	(6)	0.00003							

b)

r	$\sigma + -\sigma -$		$\varrho - \mu$		$\kappa -, \kappa$	
	Nb	Nd	Nb	Nd	Nb	Nd
200	0.085	0.074	0.043	0.089	(0.50)	0.26
300	.051	.048	.020	.047	.22	.19
400	.027	.025	.025	.020	0.13	0.10
500	.022	.023	.011	.010		
600	.018	.017	.010	.009		
700	.017	.014	0.010	0.010		
800	.014	.010				
900	0.012	0.009				

These values inserted in x_1 and x_2 give the following values of γ_1 and γ_2 :

$m =$	6	7	8	9	10
$\gamma_1 =$	0.61	0.21	0.03	0.00	0.00
$\gamma_2 =$	0.02	0.09	0.39	0.78	0.95

The densities and star-numbers then obtained are also given in Table 16. The corresponding curve is dotted in Fig. 8. — The observed curve of reg. *Nb* could also be represented by the equation $D(r) = 6.6 r^{-1.22}$, and we then get the same value for ε and $\varrho_1 = 15.0$.

b) The τ - stars. We put

$$D(r) = 0.00150 e^{-\frac{1}{3}(\varrho - 15.5)^2}$$

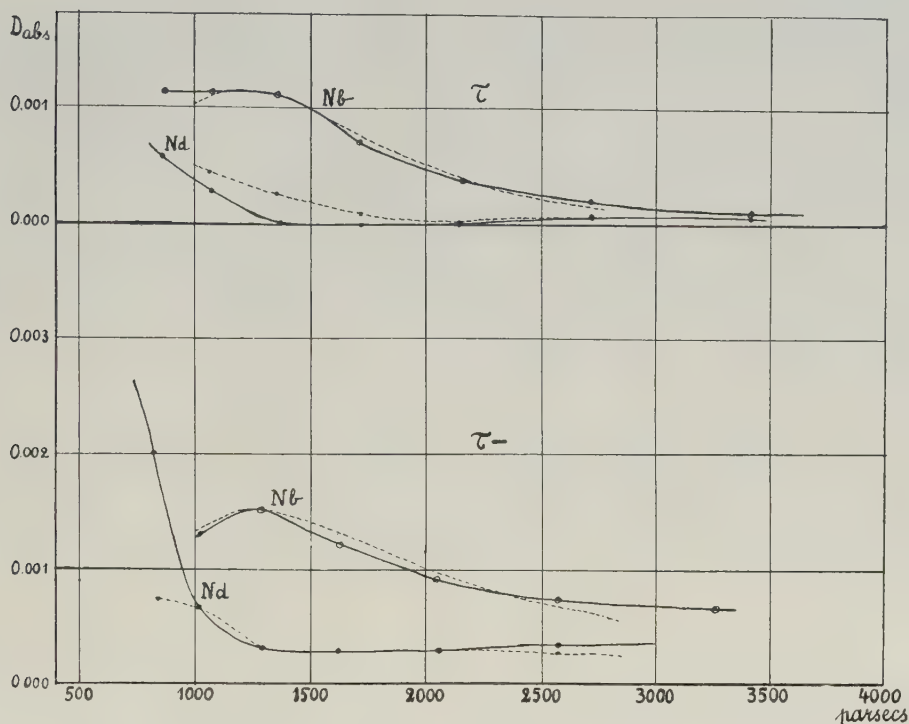


Fig. 8. Density curves for the τ groups in the regions *Nb* and *Nd* of Cepheus (dotted curves: the assumed curves of *Nb* and computed curves of *Nd*).

for the observed density curve of reg. *Nb*. The constants are

$$\begin{aligned} \varrho_0 &= 15.5, & \alpha^2 &= 1.5, \\ M_0 &= -1.7, & \sigma &= 0.5, \end{aligned}$$

which give

$$\begin{aligned} x_1 &= 1.53 \varrho_1 - 1.31 m & - 12.60 \\ x_2 &= 1.53 \varrho_1 - 1.31 (m - \varepsilon) - 12.60. \end{aligned}$$

We obtain the best representation of the observed curve in *Nd* by taking

$$\begin{aligned} \varrho_1 &= 15.5, & \varepsilon &= 1.0, \\ r_1 &= 1260 \text{ parsecs.} \end{aligned}$$

The values of γ_1 and γ_2 calculated with these numbers are:

$m =$	6	7	8	9	10
$\gamma_1 =$	1.00	1.00	0.81	0.16	0.00
$\gamma_2 =$	0.00	0.00	0.00	0.19	0.84.

The computed star-numbers, densities, and density curve are given in Table 16 and Fig. 8.

Under the presumption that the region Nb is not affected by obscuring matter at small distances we may conclude from the results just obtained that the darkness of region Nd is caused by a dark nebula at a distance of about 1200 parsecs absorbing 1—2 magnitudes of the star-light. We shall see later, however, that this presumption is *probably not true*. — It is worthy of notice that LUNDMARK for a cluster and a bright and dark nebula situated at $RA = 21$ h. 36 m., $D = +57^\circ 2'$ has found a distance of about 1100 parsecs.¹

It can be remarked that similar results as to the characteristics of the dark nebula are obtained from a study of the numbers $B(m)$. I do not think it necessary to give any details here.

Comparing now the results for the other luminosity groups of the two areas N , we find according to Table 16 b that the densities for the σ , ϱ , and π groups are nearly the same in the bright and the dark regions, the run of the density curves exactly similar. It follows from this that *if obscuring matter is to be found at small distances in reg. Nb it must extend also to Nd and affect the distribution of the stars in exactly the same manner in both regions.* We shall return to this question below (§ 5) after having studied regions S and S_1 .

3. Region S , gal. lat. about -3° . The division of this area into two parts is legitimate according to Fig. 7. Branches of dark nebulae seem to be projected on the bright back-ground and may influence the star-numbers and densities. In Table 17 I give the observed densities for regions Sb and Sd . The corresponding curves for the τ groups are given in Fig. 9. A remarkable feature in the τ curve for the bright region is the very slow decrease of the density even to the greatest distances. The densities for the τ stars in reg. Sd are exceedingly small. For the σ and ϱ groups the densities show no great differences in the two areas, but for the π stars they are considerably greater in Sb .

As to the possible existence of absorbing matter in region Sd it must be said that the curves for the τ groups afford scarcely any positive evidence. The τ — curve of reg. Sd does not show the rapid decrease characteristic of the influence of a nebula. The π curve of Sd is known for rather short an interval of distances, so that it is difficult to draw any conclusions.

¹ LUNDMARK, The parallaxes etc. p. 47, Publ. of Astr. Soc. of the Pac., vol. 34, 40 (1922). De mörka nebulosornas utbredning, Pop. astr. tidskr., VII, p. 18, Meddel. fr. Astr. observ. Upsala, No. 12 (1926).

Table 17.

Space density in the region S of Cepheus.

a)

r	τ, Sb		τ, Sd				r	$\tau-, Sb$		r	$\tau-, Sd$			
	n	$D_{\text{abs.}}$	$n_{\text{obs.}}$	$D_{\text{abs.}}$ (obs.)	$n_{\text{comp.}}$	$D_{\text{abs.}}$ comp.		n	$D_{\text{abs.}}$		$n_{\text{obs.}}$	$D_{\text{abs.}}$ (obs.)	$n_{\text{comp.}}$	$D_{\text{abs.}}$ (comp.)
1182	0.5	0.00022					516	1	0.005	493			0.5	0.003
1489	2	.00044					650	1.5	.004	621			1	.002
1875	2	.00022	0.5	0.00006	0.5	0.00006	818	2.5	.003	781	0.5	0.001	1	.001
2359	2	.00011	1.5	.00008	2	.00011	1030	4	.00265	984	2	.002	1	.001
2970	4	.00011	1.5	.00004	2	.00006	1297	6	.00199	1238	2.5	.00097	2	.00088
3740	7	.00010	2.5	.00004	2	.00003	1632	8.5	.00139	1559	3.5	.00068	4	.00079
4709	12	.00008	3	0.00002	2	0.00001	2055	15	.00119	1963	6	.00058	5.5	.00057
5928	20	0.00007					2587	27	0.00113	2471	10	0.00049	6.5	0.00032

b)

r	$\sigma + - \sigma -$		$\varrho - \mu$		$\kappa -, \varkappa$	
	Sb	Sd	Sb	Sd	Sb	Sd
200			0.141	0.044	0.36	0.12
300	0.045	0.060	.063	.034	.22	.075
400	.060	.034	.060	.050	0.11	0.078
500	.060	.042	.043	.046		
600	.052	.041	.036	.036		
700	.044	.037	0.032	.028		
800	.038	.031		0.024		
900	0.030	0.023				

Let us, however, represent the τ curve of the region Sb by

$$D(r) = \text{const.}$$

We then have the following values:

$$\begin{aligned} s &= 0, \\ M_0 &= -3.3, \quad \sigma = 0.7, \end{aligned}$$

and get, according to formulae (8) of ch. V, the equations

$$x_1 = 1.01 \varrho_1 - 1.01 m - 9.07$$

$$x_2 = 1.01 \varrho_1 - 1.01 (m - \varepsilon) - 9.07.$$

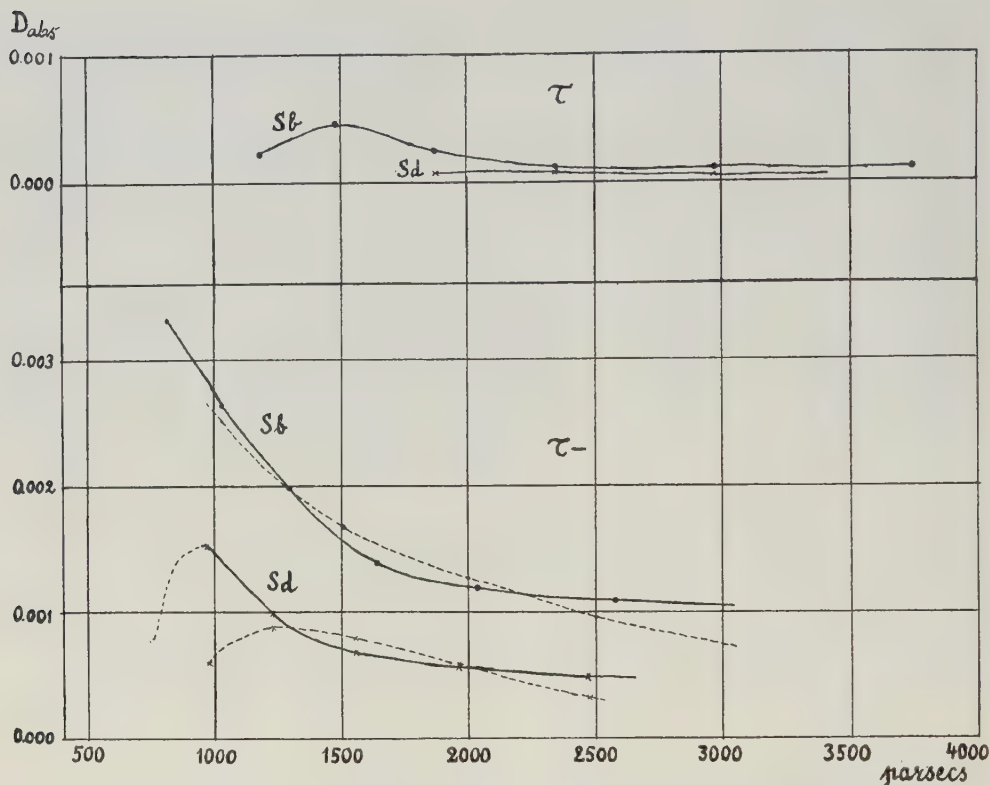


Fig. 9. Density curves for the τ groups in the regions Sb and Sd (Cepheus) (dotted curves: the assumed curve of Sb and the computed one of Sd).

From them we find the values

$$\varrho_1 = 15.2, \quad \varepsilon = 1.5,$$

$$r_1 = 1100 \text{ parsecs.}$$

γ_1 and γ_2 then get the following values for different m :

$m =$	6	7	8	9	10
$\gamma_1 =$	0.62	0.13	0.02	0.00	0.00
$\gamma_2 =$	0.02	0.16	0.66	0.95	1.00

The densities then computed are given in Table 17 and reproduce the observed densities very well.

Passing now to the τ - group the curve in Sb may be represented by

$$D(r) = 8.7 r^{-1.17}.$$

Thus we have

$$\begin{aligned} s &= 1.17, \\ M_0 &= -1.7, \quad \sigma = 0.5, \\ x_1 &= 1.41 \varrho_1 - 1.41 m - 9.77 \\ x_2 &= 1.41 \varrho_1 - 1.41 (m - \varepsilon) - 9.77. \end{aligned}$$

We arrive at the following values of γ_1 and γ_2

$m = 6$	7	8	9	10
$\gamma_1 = 0.96$	0.57	0.03	0.00	0.00
$\gamma_2 = 0.00$	0.04	0.42	0.94	1.00

calculated with

$$\begin{aligned} \varrho_1 &= 14.0, \quad \varepsilon = 1.0, \\ r_1 &= 630 \text{ parsecs,} \end{aligned}$$

which give the dotted curve in Fig. 9. It is not possible to get better agreement with other values of ϱ_1 and ε .

It is not easy to interpret these diverging results from the τ and τ - stars. *They do not support the hypothesis of an absorbing nebula.* If there were an absorbing nebula it could possibly be assumed that its distance was in reality greater than what has appeared from the τ stars, so great that it would have no influence on the observed part of the τ - curve. In such a case the small number of τ - stars in Sd would be explained as an effect of the rapid thinning out of such stars when leaving the galactic plane (as the gal. lat. of reg. Sd is a little higher than that of Sb). An examination of the star-numbers $\log B(m)$ gives no better idea of the cause of the small number of τ and τ - stars in the region Sd .

4. *Region S_1 , gal. lat. about -10° .* This region has been studied separately in order to examine the influence of galactic latitude on the curves. The space densities for the different groups are given in Table 18.

5. *Comparison of results from the different regions in Cepheus. Influence of galactic latitude.* We shall now discuss the possible existence of an absorbing nebula at a relatively small distance in region N . We use the stars of the types of low luminosity. The number of τ and τ - stars at small distances is too insignificant.

Table 18.

Space density in the region S_1 of Cepheus.

r	τ		$\tau -$		r	$\sigma + - \sigma -$	$\varrho - \mu$	$\kappa - , \kappa$
	n	$D_{\text{abs.}}$	n	$D_{\text{abs.}}$				
392	0.5	0.003	0.5	0.003	150			0.12
493	0.5	.002	1.5	.005	200		0.028	.07
621	0	.000	1.5	.002	300	0.020	.023	.06
781	1	.001	2	.002	400	.012	.030	.05
984	1.5	.00062	5	.00207	500	.024	.031	0.05
1238	1	.00021	7.5	.00155	600	.029	.025	
1559	2	.00021	8	.00083	700	.027	0.020	
1963	1.5	.00007	6.5	0.00033	800	.022		
2471	0	.00000			900	0.018		
3110	1	.00002						
3917	2	0.00002						

It was pointed out that for the groups σ and ϱ the density curves for the two N -regions were nearly identical, and the same result was obtained as regards the S -regions. It is, therefore, of interest to compare the results for region N as a whole with those of region S as a whole. In Table 19 the densities for the σ and ϱ groups within these two areas are given. The corresponding density curves for all the groups combined as well as that for region S_1 are drawn in Fig. 10. For the regions S and S_1 the two curves have the same general run, although the S_1 -densities are considerably smaller than those of S , owing, of course, to the influence of galactic latitude. The

Table 19.

Space density in the regions N and S .

r	$\sigma + - \sigma -$		$\varrho - \mu$	
	N	S	N	S
200			0.068	0.080
300	0.065	0.055	.024	.062
400	.032	.051	.018	.050
500	.016	.047	.012	.040
600	.014	.045	0.008	.032
700	.013	.040		0.028
800	0.012	0.032		

great constancy of the density within the whole distance interval is worthy of being noticed. In region *N* the curve has quite another appearance: the densities decrease rather rapidly between 300 and 500 parsecs being after that nearly constant. It is evident that the darkness of the whole of region *N* in relation to the whole of region *S* is caused by a nebula situated at a comparatively small distance.

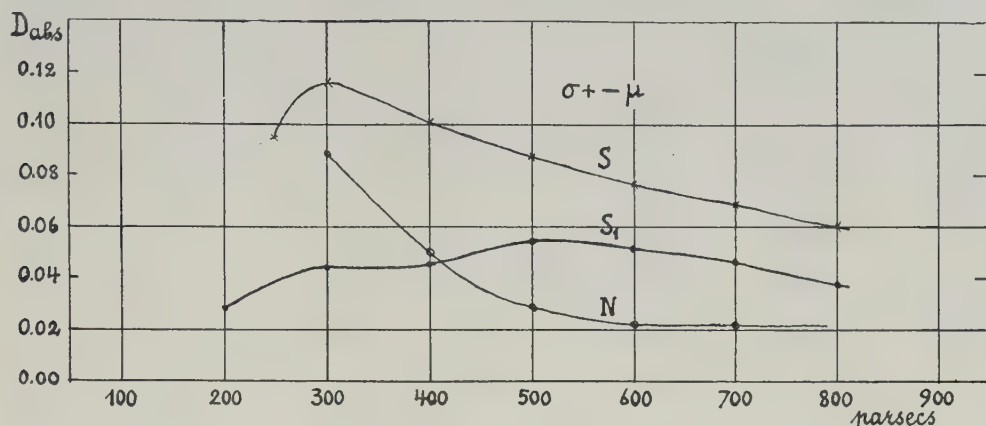


Fig. 10. Density curves for the groups $\sigma+ - \mu$ in Cepheus.

In order to derive this distance and the absorbing power of the nebula we shall examine the star-numbers within each one of the groups $\sigma+$; $\sigma, \sigma-$; ϱ, μ ; and $\kappa-, \kappa$. This will furnish sufficient evidence as to this nebula. We have the following $\log B(m)$ in the two areas:

Star-numbers $\log B(m)$.

<i>m</i>	$\sigma+$			$\sigma, \sigma-$			ϱ, μ			$\kappa-, \kappa$		
	<i>S</i>	<i>N</i>	$\Delta \log B$	<i>S</i>	<i>N</i>	$\Delta \log B$	<i>S</i>	<i>N</i>	$\Delta \log B$	<i>S</i>	<i>N</i>	$\Delta \log B$
10.5	2.03	1.69	+0.34	2.15	1.79	+0.36	1.94	1.58	+0.36	1.82	1.85	-0.03
9.5	1.68	1.23	.45	1.72	1.46	+ .26	1.54	1.23	0.31	1.45	1.52	.07
8.5	1.20	0.78	.42	1.15	1.15	0.00	1.00	0.90	0.10	0.85	1.18	.33
7.5	0.70	0.48	+0.22	$-\infty$	0.60		0.70	0.60	+0.10	0.30	0.60	-0.30
6.5	0.00	0.30	-0.30		0.00		0.00			0.00		

For the groups $\sigma+$; $\sigma, \sigma-$; and κ the number of bright stars is greater in the dark region than in the bright. This is a phenomenon pointed out by WOLF several times in his star-counts in bright and dark regions. It is evident from the curves $\log B(m)$ given in Fig. 11 that there is really an absorbing medium in region *N*. It is to be observed that the stars of the κ group do not reveal the existence of the nebula, at least not clearly. This is not surprising, however, as most of the κ stars are situated at a distance smaller than that derived below for the nebula. Using the other groups the

distance where the nebula begins to influence the star-numbers and the absorption ε of the nebula are deduced from the data:

- a) the $\sigma +$ stars: $m=7.0$, $M=-0.4$ give $r=302$ parsecs. The curves: $\varepsilon=1.0$.
 b) » $\sigma, \sigma-$ » $m=8.5$, $M=+0.3$ » $r=437$ » » » $\varepsilon=0.8$.
 c) » ϱ, μ » $m=8.8$, $M=+1.0$ » $r=363$ » » » $\varepsilon=0.9$.

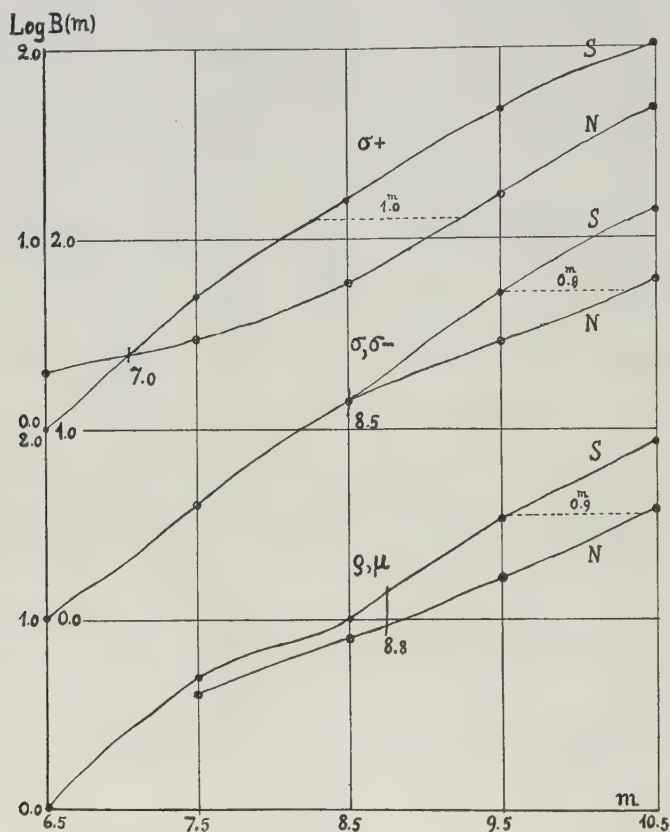


Fig. 11. Graphical representation of the star-numbers in the regions N and S of Cepheus.

In the mean we thus get the following values

$$r = 370 \text{ parsecs.}$$

$$\varepsilon = 0.9 \text{ mag.}$$

O. STRUVE, in his research on interstellar calcium¹, has investigated particularly a region in Cepheus that coincides very nearly with my regions. STRUVE has made star-counts in one area at $RA\ 22^h\ 10^m$, $D + 52^\circ$ ($\sim$ region S), and in another at $RA\ 21^h\ 55^m$, $D + 58^\circ$ ($\sim$ region N). From

¹ O. STRUVE, Interstellar Calcium, Mount Wilson Contr., No. 331, Astrophys. Journal, 65, 163 (1927).

B, *A*, and *F* stars (according to the Draper Catalogue) he finds that the nearer edge of the dark nebula begins at 400 parsecs. From counts of stars down to magnitudes 15—16 without regard to spectral type he finds that the number of bright stars in the dark region is greater than that in the bright. From all the stars he derives a distance of 330 parsecs for the nearer edge of the nebula and an absorption of 0.8 mag. STRUVE identifies this nebula with that of LUNDMARK (at a distance of more than 1000 parsecs). But now it is shown above from the study of the τ and $\tau-$ stars in regions *Nb* and *Nd* that there must be also a second nebula in reg. *Nd* at a great distance. Thus, the first nebula found here corresponds to that of STRUVE at a distance of hardly 400 parsecs, the second probably to that of LUNDMARK at a distance of more than 1000 parsecs *when no regard is paid to the absorbing influence of the first nebula* (cf. below). The nearer nebula is probably connected with the great clouds of interstellar calcium found in Cepheus.

Of course the neighbouring dark nebula covering the whole region *N* must have a sensible influence upon our determination of the distance of the second nebula in reg. *Nd* from the τ groups, as the brightness of all the stars in reg. *N* at distances greater than 370 parsecs is diminished with nearly one magnitude. The quantity ϱ_0 is diminished by nearly one unit as $\varrho = m - M + 5$. In order to get the same values for x_1 and x_2 for, not the same, but the corresponding m -values as before, we derive the following relation between the changes $\Delta\varrho_1$, $\Delta\varrho_0$, and Δm :

$$(\alpha^2 + \sigma^2) \Delta\varrho_1 = \sigma^2 \Delta\varrho_0 + \alpha^2 \Delta m$$

that is, we get: $\Delta\varrho_1 = \Delta\varrho_0$, as $\Delta m = \Delta\varrho_0$. The change in ϱ_1 is thus, in the present case, about 0.9, *the distance of the nebula is, consequently, diminished from 1200 parsecs to only about 800 parsecs*. This result has naturally no influence upon our conclusion concerning the stars of the classes of low luminosity in region *N*.

It is very difficult to derive results for the distribution of the stars in the Cepheus region with regard to galactic latitude as there are absorbing nebulae in many parts of the region changing the true distribution. In Fig. 12 I have drawn for the τ groups the lines of equal density using the three areas *Nb*, *Sb*, and *S₁*. But no regard was paid to the influence of the neighbouring nebula in reg. *Nb*; thus these points for *Nb* should be removed some-

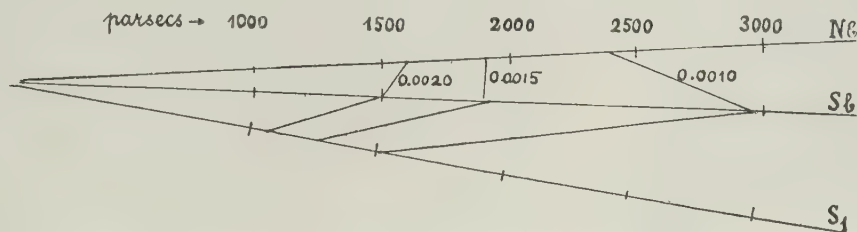


Fig. 12. Equi-density lines for the τ and $\tau-$ stars in Cepheus.

what to the right in order to represent the real densities. The figure may be of interest because it shows very clearly the rapid decrease of density in reg. S_1 as well as the slow decrease in the star-rich region Sb . This great difference in decrease of density depends partly on the difference in galactic latitude between the two areas, partly on a real agglomeration of stars in region Sb .

For the groups of lower luminosity Fig. 10 shows best the influence of galactic latitude.

C. The region in Cassiopeia (gal. long. about 98°).

This region embraces an area of nearly 70 square degrees. The galactic plane cuts the region into two parts of which the south part is the largest one. The region is found on Plates 7 and 8 of Lick Publ. XI. A part of Plate 7 is reproduced here in Fig. 13. ϵ Cas is situated in its north part. — There are no sharp limits between bright and dark parts of this region as was the case in those previously studied. For the statistical treatment the region was divided into two parts, one *bright, region B*, and the other *dark, region D*, see Fig. 13.

Table 20.

Number of stars and area densities in the Cassiopeia region.

m	Reg. B: 27.2°					Reg. B central 5.3°		Reg. B outer 21.9°		Reg. D: 41.3°				
	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$	τ	$\tau-$	τ	$\tau-$	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$
10.6—11.0	22	40	63	44	17	10	14	12	26	20	18	56	38	17
10.1—10.5	20	25	44	13	12	6	9	14	16	14	21	30	20	12
9.6—10.0	29	16	23	15	8	16	5	13	11	14	15	30	11	24
9.1— 9.5	11	6	19	8	6	3	0	8	6	5	6	22	7	7
8.6— 9.0	11	5	15	7	3	3	0	8	5	3	3	9	5	6
8.1— 8.5	2	7	3	4	3	0	2	2	5	3	1	5	3	3
7.6— 8.0	2	3	6	2	0	1	0	1	3	4	2	4	2	1
7.1— 7.5	3	2	1	0	0	2	0	1	2	0	2	3	2	0
6.6— 7.0	0	0	0	1	1	0	0	0	0	0	0	3	0	0
6.1— 6.5	1	3	1	2	0	0	2	1	1	0	0	0	1	0
≤ 6.0	0	3	0	0	0	0	1	0	2	1	0	2	1	0
Total numb. ≤ 10.5	79	70	112	52	33	31	19	48	51	44	50	108	52	53
Area dens. stars ≤ 10.5	2.90	2.57	4.12	1.91	1.21	5.85	3.58	2.19	2.33	1.07	1.21	2.62	1.26	1.23

Total number of stars with $m \leq 10.5 = 653$.

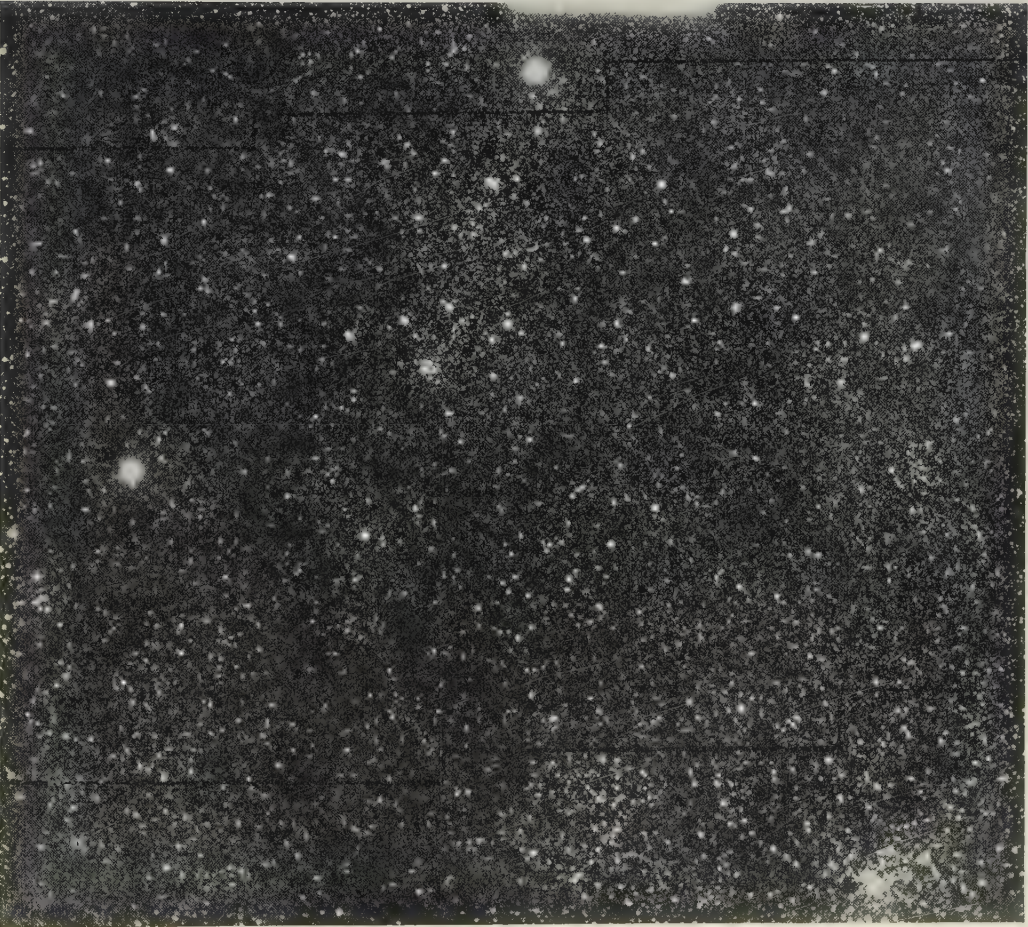
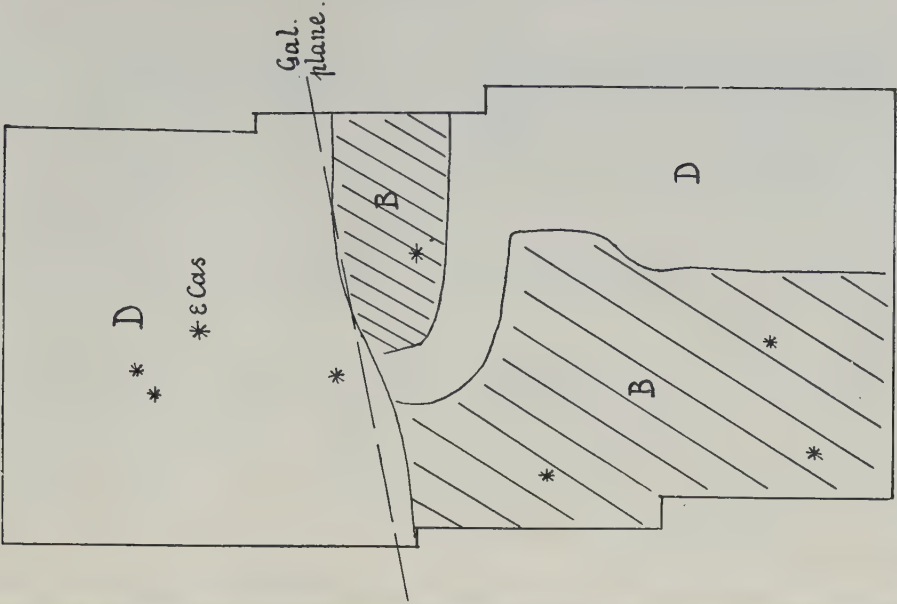


Fig. 13. The Cassiopeia region. To the right: the subdivision into smaller areas. To the left: a reproduction of Plate 7 in Lick Publ. XI showing this region of the Milky Way.



In Table 20 are given the number of stars of different luminosity classes and apparent photographic magnitudes within the Cassiopeia region. In this the numbers for the τ groups are given for two parts of area B , namely, one central, very bright part, and another greater part (see Fig. 13). The very strong concentration of the τ and $\tau-$ stars in the small central part of the bright area is obvious. Comparing the regions B and D we find that the greatest differences in area density occur within the τ groups but that also for the classes $\sigma+$ to μ the densities are considerably greater for reg. B than for reg. D .

At first each of the two parts of the bright region was treated separately but as there was no greater difference in the general run of the curves the results were combined for the whole region B . I give in Table 21 the space densities for the τ groups in the regions B and D . For the τ stars in B the density is very constant up to great distances, also for the $\tau-$ stars at distances >1500 parsecs. For region D the densities are small. The density curves are drawn in Fig. 14.

For the other luminosity classes the space densities are found in Table 22. The densities for reg. D are, in general, smaller than the corresponding ones in reg. B .

Now the question arises whether the small densities for the poor region — especially within the τ groups — are caused by absorbing nebulae. This may be expected as the $\tau-$ curve for the dark region shows a sudden decrease to 1000 parsecs and afterwards a constant run (see Fig. 14). It seems, however, rather difficult to get a fair representation of both curves for the τ groups as will be seen from the following computation.

Table 21.

Space density for the τ groups in the regions B and D of Cassiopeia.

r	τ, B		τ, D				$\tau-, B$				$\tau-, D$			
	n	$D_{\text{abs.}}$	n obs.	$D_{\text{abs.}}$ (obs.)	n comp.	$D_{\text{abs.}}$ (comp.)	r	n	$D_{\text{abs.}}$	n obs.	$D_{\text{abs.}}$ (obs.)	r	n comp.	$D_{\text{abs.}}$ (comp.)
593			0.5	(0.0008)			259	0.5	(0.015)					
746			0.5	(.0004)	0.5	(0.0004)	325	2	.031			311	2	0.023
940	0.5	(0.0003)	0	.0000	0.5	(.0002)	410	2	.015			392	2	.012
1182	1	.0003	1	.0002	0.5	(.0001)	516	1	.004	1	0.0025	493	2	.006
1489	2	.00032	1.5	.00016	2	.00021	650	2	.004	2	.0025	621	1.5	.002
1875	4	.00032	2.5	.00013	2	.00010	818	3	.003	1.5	.0009	781	2	.0014
2359	5	.00020	3	.00008	2.5	.00006	1030	4	.00192	1	.0003	984	1.5	.0006
2970	7	.00014	4.5	.00006	3.5	.00005	1297	6.5	.00157	2.5	.00040	1238	1.5	.00029
3740	16	.00016	6.5	.00004	4.5	.00003	1633	7.5	.00088	5.5	.00045	1559	3	.00029
4709	(23)	0.00012	11	0.00004	9	0.00003	2055	12	.00073	11	.00043	1963	5	.00023
							2587	22	0.00065	19	.00038	2471	7	0.00017
							3257			(31)	0.00030			

Table 22.

Space density for the σ , ϱ , and κ groups in the regions B and D of Cassiopeia.

r	$\sigma + \sigma -$		$\varrho - \mu$		$\kappa -, \kappa$	
	B	D	B	D	B	D
100			(0.37)	(0.24)		
200	0.082	0.046	0.050	0.068	0.17	0.14
300	.041	.050	.079	.088	.11	.12
400	.088	.026	.055	.028	0.08	0.10
500	.029	.018	.040	.021		
600	.026	.015	.032	.018		
700	.022	.014	.025	.017		
800	.021	.012	.022	.016		
900	.020	.012	0.021	0.016		
1000	0.017	0.011				

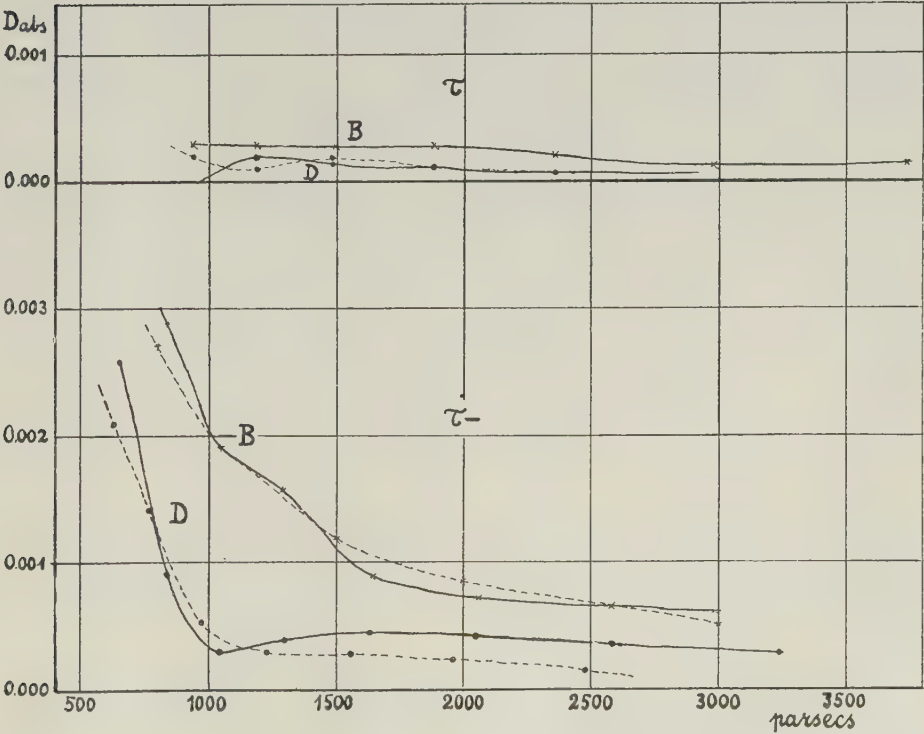


Fig. 14. Density curves for the τ groups in Cassiopeia (dotted curves: assumed curve of B and computed curve of D)

a) Starting from the τ stars of reg. B where the density can be considered as constant we have:

$$s=0, \\ M_0=-3.3, \quad \sigma=0.7,$$

which give

$$x_1=1.01 \varrho_1-1.01 m \quad -9.07, \\ x_2=1.01 \varrho_1-1.01 (m-\varepsilon)-9.07.$$

They give the best approximation to the observed curve in D for

$$\varrho_1=15.0, \quad \varepsilon=1.0.$$

The corresponding values of γ_1 and γ_2 are then:

$m=$	6	7	8	9	10
$\gamma_1=$	0.51	0.08	0.00	0.00	0.00
$\gamma_2=$	0.07	0.49	0.92	1.00	1.00.

b) The τ - curve of the bright region may be represented by

$$D(r) = 13.3 r^{-1.27}.$$

With

$$s=1.27, \\ M_0=-1.7, \quad \sigma=0.5,$$

we get

$$x_1=1.41 \varrho_1-1.41 m \quad -9.75 \\ x_2=1.41 \varrho_1-1.41 (m-\varepsilon)-9.75.$$

Taking

$$\varrho_1=14.5, \quad \varepsilon=1.5,$$

we find

$m=$	6	7	8	9	10
$\gamma_1=$	1.00	0.88	0.21	0.00	0.00
$\gamma_2=$	0.00	0.00	0.04	0.44	0.94

and get the best possible representation of the observed curve in reg. D . The computed densities for great distances are, however, considerably smaller than the observed ones, so that the result is not satisfactory. See Table 21 and Fig. 14.

A direct examination of the star-numbers gives no support to the assumption of an absorbing nebula. I give here, for the sake of brevity, only the differences $\Delta \log B(m)$ for the classes τ to μ :

Differences $\Delta \log B(m)$.

m	τ	$\tau -$	$\sigma + - \sigma -$	$\varrho - \mu$
10.5	+0.44	+0.32	+0.20	+0.18
9.5	.46	.49	+ .15	.24
8.5	.18	.74	- .01	.18
7.5	.78	+0.78	- .42	.06
6.5	+0.18		-0.12	+0.18

The τ groups do not reveal the existence of any distant nebula. Nor can there be any adjacent nebula, for the $\Delta \log B(m)$ for the ϱ stars vary rather irregularly.

From the above calculations the conclusion may be drawn that *it seems to be rather doubtful whether the darkness of reg. D is caused by an absorbing nebula*. The irregularities of the surface distribution perhaps reproduce here real irregularities in the space distribution of the stars.

As the density curves for the classes $\sigma +$ to μ do not diverge very much for the regions B and D I have also computed the space densities for these classes combining both areas. The results are given in Table 23 which will be used in § 2 of the next chapter.

Table 23.

Space density for the whole Cassiopeia region (regions B and D combined).

r	$\sigma + - \sigma -$	$\varrho - \mu$	$\kappa -, \kappa$
100			
200	0.061	0.072	0.15
300	.052	.052	.12
400	.031	.040	0.09
500	.022	.030	
600	.019	.023	
700	.019	.020	
800	.018	0.019	
900	0.017		

D. The region in Auriga (gal. long. about 134°).

1. Three plates including an area of 76 square degrees cover this region which embraces parts of the most variable structure (see Fig. 15): A very bright star-cloud is situated in the galactic plane; to the north of the plane the star-numbers decrease continually. South of the galactic plane towards

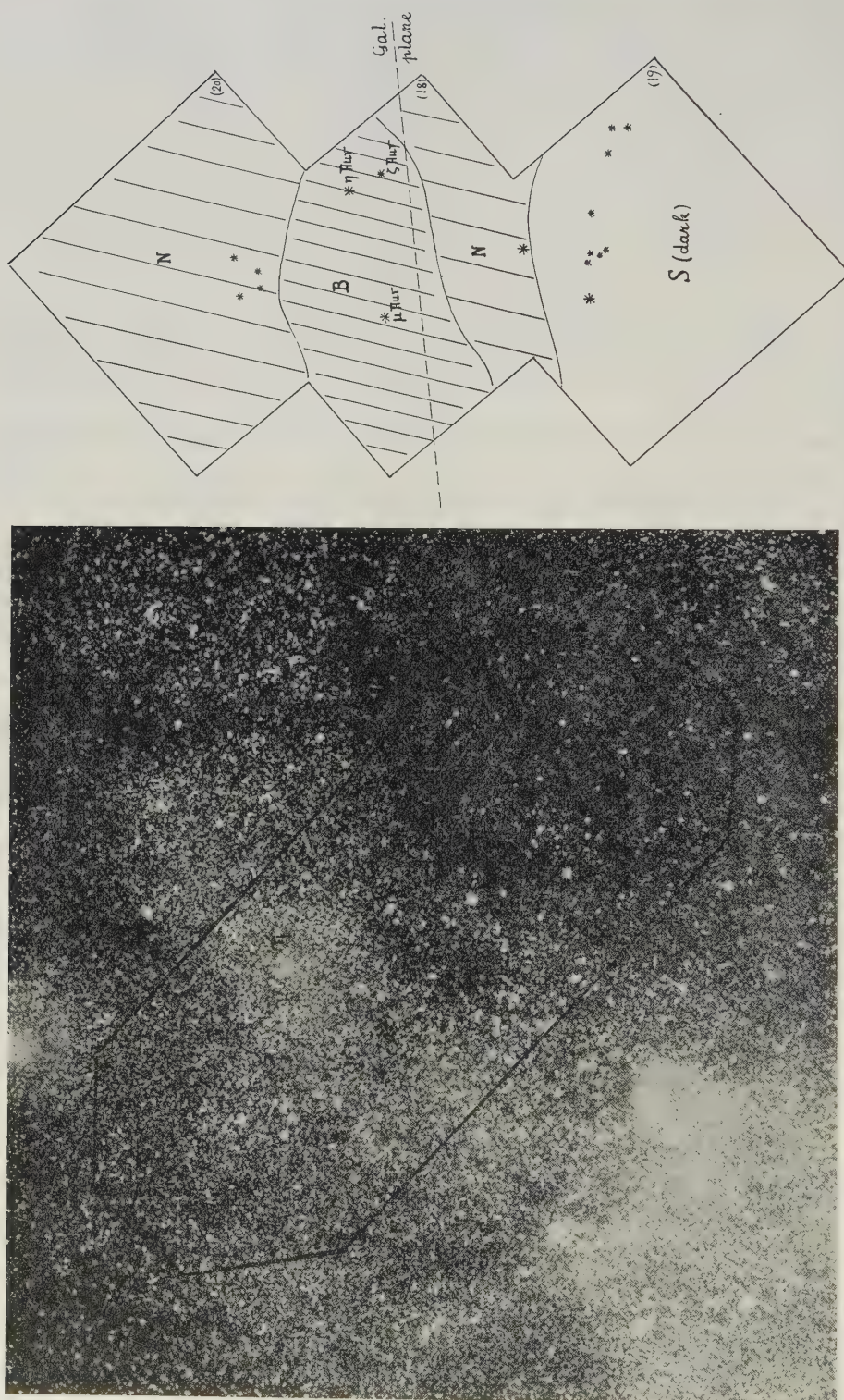


Fig. 15. The Auriga region. To the right: the subdivision into smaller areas. To the left: a photograph by WOLF (from »Die Milchstrasse») showing this region of the Milky Way.

Taurus, we find a dark region with very small surface density. — For the statistical treatment the region was divided into three parts, Fig. 15. *Region N* lies to the *north* of the galactic plane but a small area between the brightest and the darkest regions is also reckoned to it; *region B* is the *bright star-cloud* in the galactic plane, and, finally, *region S* the dark region *south* of the galactic plane, in the direction of Taurus.

The very great inequalities between the different areas are shown in Table 24 where the number of stars and the area densities are given, in the

Table 24.
Number of stars and area densities in the Auriga region.

<i>m</i>	Reg. <i>N</i> : 33.0 □°					Reg. <i>B</i> : 16.6 □°					Reg. <i>S</i> : 27.0 □°				
	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$	τ	$\tau-$	$\sigma+-\sigma-$	$\varrho-\mu$	$\kappa-, \kappa$
10.6—11.0	3	6	37	50	21	2	12	47	24	10	0	0	4	2	5
10.1—10.5	2	10	29	41	31	1	15	38	22	12	1	1	5	4	6
9.6—10.0	1	14	21	30	15	5	18	33	7	8	2	1	3	4	2
9.1— 9.5	0	9	23	11	10	0	11	19	1	3	0	0	0	2	0
8.6— 9.0	0	6	14	8	4	3	7	9	8	1	0	0	3	1	2
8.1— 8.5	0	4	4	2	3	4	5	1	1	2	0	1	0	0	1
7.6— 8.0	1	3	5	1	0	1	3	4	2	0	0	2	2	0	0
7.1— 7.5	0	1	4	0	0	1	1	0	1	1	0	0	1	0	0
6.6— 7.0	0	0	1	1	0	2	1	0	1	0	0	0	0	0	0
6.1— 6.5	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0
≤6.0	0	0	1	2	1	0	1	0	1	0	0	0	0	0	0
Total numb. ≤10.5	4	47	103	96	64	17	62	105	44	27	4	5	14	11	11
Area dens. stars ≤10.5	0.12	1.42	3.12	2.91	1.94	1.02	3.74	6.32	2.65	1.63	0.15	0.19	0.52	0.41	0.41

Total number of stars with $m \leq 10.5 = 614$.

same manner as for the preceding regions. The most striking fact shown by this table is *the extremely small number of stars of all groups in the dark region S*, and the corresponding small area densities. Other interesting features are the small number of τ stars in the Auriga region, and the very strong concentration of stars of the τ groups in the bright area *B*. The great number of faint stars is also remarkable for several groups in regions *N* and *B*, indicating, in many cases, a nearly constant star-density. For the regions *N* and *B* the main difference lies in the number of τ and $\tau-$ stars.

2. *On an eventual dark nebula in region S.* We are now going to study the space density, and then we begin with the groups of low luminosity in order to examine the cause of the darkness in region *S*. It has shown itself

that for these luminosity groups practically no difference exists in the general run of the density curves for regions N and B . Therefore, the results are not given here separately. The two regions were combined, and, starting from the density curves thus obtained, I have tried to deduce the distance of an eventual dark nebula in region S .

Table 25.

Space density for the classes $\sigma+$ to κ in Auriga.

r	$\sigma+$ $N+B$	$\sigma+, S$		$\sigma, \sigma-$ $N+B$	$\sigma, \sigma-, S$		ϱ, μ $N+B$	ϱ, μ, S		$\kappa-$ $N+B$	$\kappa-, S$		κ $N+B$	κ, S	
		obs.	comp.		obs.	comp.		obs.	comp.		obs.	comp.		obs.	comp.
100							(0.20)			(0.12)				(0.12)	
200	0.029			0.025			0.085			.094	0.053	0.030		.002	
300	.018			.022	0.020	0.009	.049	(0.009)	(0.009)	.084	.022	.016	0.047	.013	(0.010)
400	.012	0.004	0.002	.015	.005	.002	.048	.012	.007	.061	0.020	0.020	.061	.016	0.005
500	.010	.002	.001	.012	.004	.005	.042	.011	.006	0.051			0.059	(0.010)	
600	.008	.001	.001	.017	.003	.004	.040	.008	.005						
700	.007	.0008	.0010	.022	.002	.003	0.039	.006	.004						
800	.006	.0005	.0007	.022	.002	.003		0.004	0.004						
900	.005	0.0004	0.0005	0.019	0.002	0.002									
1000	0.004														

In Table 25 the space densities are given for the regions N and B combined within each of the groups $\sigma+$ to κ . For the dark region the densities are also given together with the computed densities. The corresponding density curves are given in Fig. 16. The results of the computations for the groups $\sigma+$ to κ are the following:

a) The $\sigma+$ stars. The density curve of reg. $N+B$ is represented by

$$D(r) = 3.4 r^{-0.94}$$

and the following constants are used:

$$s = 0.94, \\ M_0 = -0.4, \quad \sigma = 0.5.$$

They give, according to ch. V, the following equations:

$$x_1 = 1.41 \varrho_1 - 1.41 m - 7.97 \\ x_2 = 1.41 \varrho_1 - 1.41 (m - \varepsilon) - 7.97.$$

Taking here

$$\varrho_1 = 10.0, \quad \varepsilon = 2.5, \tag{a}$$

we find

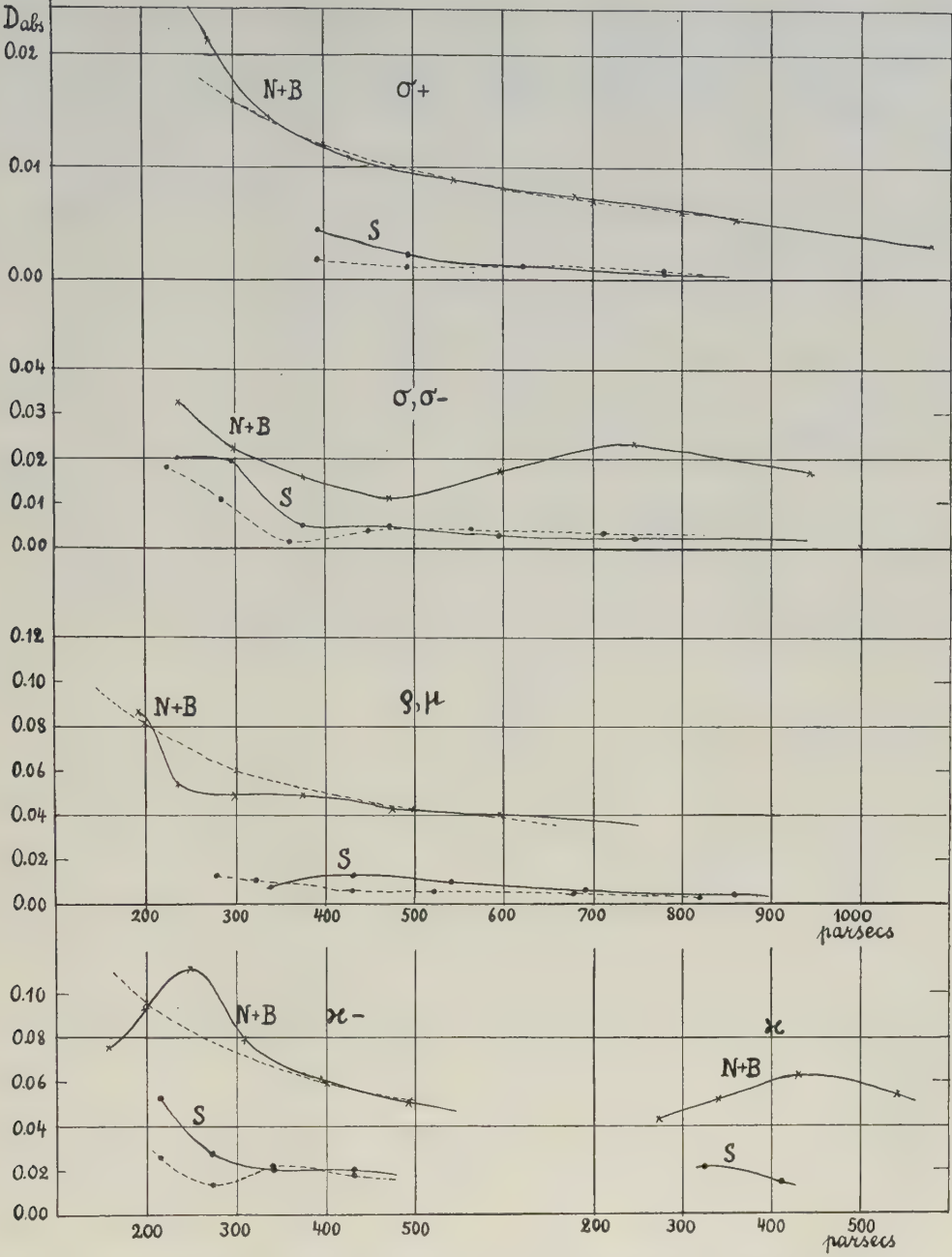


Fig. 16. Density curves for the groups σ_+ to κ in Auriga (dotted curves: assumed curve for reg. $N+B$, computed curve for reg. S .)

$m = 6$	7	8	9	10
$\gamma_1 = 0.00$	0.00	0.00	0.00	0.00
$\gamma_2 = 0.06$	0.62	0.97	1.00	1.00

and get the dotted curve in Fig. 16 in nearly complete agreement with the observed curve for region S .

b) The σ, σ - stars. The density curve for this group shows rather great irregularities in region $N+B$. We take $D(r) = \text{const.}$ and have then

$$s=0,$$

$$M_0 = +0.3, \quad \sigma = 0.5.$$

From these values:

$$x_1 = 1.41 \varrho_1 - 1.41 m \quad -7.13$$

$$x_2 = 1.41 \varrho_1 - 1.41 (m - \varepsilon) - 7.13.$$

We find with

$$\varrho_1 = 12.0, \quad \varepsilon = 1.5, \tag{b}$$

the γ_1, γ_2 -values:

$m = 6$	7	8	9	10
$\gamma_1 = 0.95$	0.45	0.04	0.00	0.00
$\gamma_2 = 0.00$	0.00	0.19	0.87	1.00.

The dotted curve thus obtained agrees rather well with the one observed.

c) The ϱ, μ stars. The curve of $N+B$ is represented by

$$D(r) = 2.8 r^{-2/3}$$

and we have

$$s = 2/3,$$

$$M_0 = +1.0, \quad \sigma = 0.5,$$

from which are derived:

$$x_1 = 1.41 \varrho_1 - 1.41 m \quad -6.03$$

$$x_2 = 1.41 \varrho_1 - 1.41 (m - \varepsilon) - 6.03.$$

The values of ϱ_1 and ε which give the best representation of the curve observed are

$$\varrho_1 = 10.0, \quad \varepsilon = 1.5. \tag{c}$$

γ_1 and γ_2 are then

$m = 6$	7	8	9	10
$\gamma_1 = 0.29$	0.02	0.00	0.00	0.00
$\gamma_2 = 0.02$	0.34	0.93	1.00	1.00.

d) The κ - stars. Starting from the density curve of $N+B$:

$$D(r) = 3.3 r^{-2/3}$$

and the constants

$$s = 2/3,$$

$$M_0 = 1.9, \quad \sigma = 0.5,$$

we get

$$x_1 = 1.41 \varrho_1 - 1.41 m - 4.76$$

$$x_2 = 1.41 \varrho_1 - 1.41 (m - \varepsilon) - 4.76$$

and find that

$$\varrho_1 = 10.0, \quad \varepsilon = 1.5 \quad (d)$$

reproduce best the curve observed in region S . γ_1 and γ_2 become

$m = 6$	7	8	9	10
$\gamma_1 = 0.89$	0.24	0.00	0.00	0.00
$\gamma_2 = 0.00$	0.04	0.41	0.94	1.00.

e) The α stars. It is hardly possible to derive any trustworthy results from this group as the density curve is known only for a small interval of distance.

The values of ϱ_1 and ε deduced from the different groups agree fairly well. The existence of an absorbing nebula in region S cannot be doubted. If we take a simple mean of all the values obtained we find

$$\varrho_1 = 10.5, \quad \varepsilon = 1.8,$$

$$r_1 = 126 \text{ parsecs.}$$

A dark nebula absorbing 1.5—2 magnitudes of the star-light is situated at a distance of about 126 parsecs in region S .

A simple study of the star-numbers would not, in this case, lead us to any definite conclusion concerning the distance of the dark nebula, because the number of stars in the dark region is very small and practically no stars are situated nearer to us than the dark nebula.

It is of great interest to find that PANNEKOEK in his researches on dark nebulae in Taurus¹ has derived a value of 140 parsecs for a nebula located between β Tau and the Pleiades, somewhat to the south of the dark nebula investigated here. The dark nebulae in these regions of the Milky Way probably belong to each other. The bright star-clouds are here separated by a great many patches of dark cosmic clouds. — These dark clouds have also affected the curves in KREIKEN's paper »On the centre of the local star system»² (his Figure 7). KREIKEN also remarks that these nebulosities have small distances.

3. The existence of a dark nebula in reg. S , at a little distance, was demonstrated in the preceding paragraph, derived from a study of the luminosity classes $\sigma+$ to α . We are now going to examine the space distribution

¹ PANNEKOEK, The distance etc. Proc. of the Kon. Ak. van Wet. te Amsterdam, 23, No. 5 (1920).

² KREIKEN, On the centre of the local star system, Month. Not., 86, 665 (1926).

Table 26.

Space density for the τ groups in the regions B and N of Auriga.

r	τ, B		$\tau-, B$		$\tau-, N$		
	n	$D_{\text{abs.}}$	n	$D_{\text{abs.}}$	r	n	$D_{\text{abs.}}$
516			0.5	0.003			
650			1.5	.005	621	1	0.002
818			2	.003	781	2	.002
1030	1	0.0008	4	.00314	984	3.5	.00158
1297	1.5	.0006	7	.00273	1238	6	.00136
1632	2.5	.0005	10	.00185	1559	8.5	.00096
2055	2.5	.00024	14	.00141	1963	13	.00076
2587	2	.00010	18	0.00088	2471	(14)	(0.00040)
3257	2.5	.00006					
4100	2	0.00002					

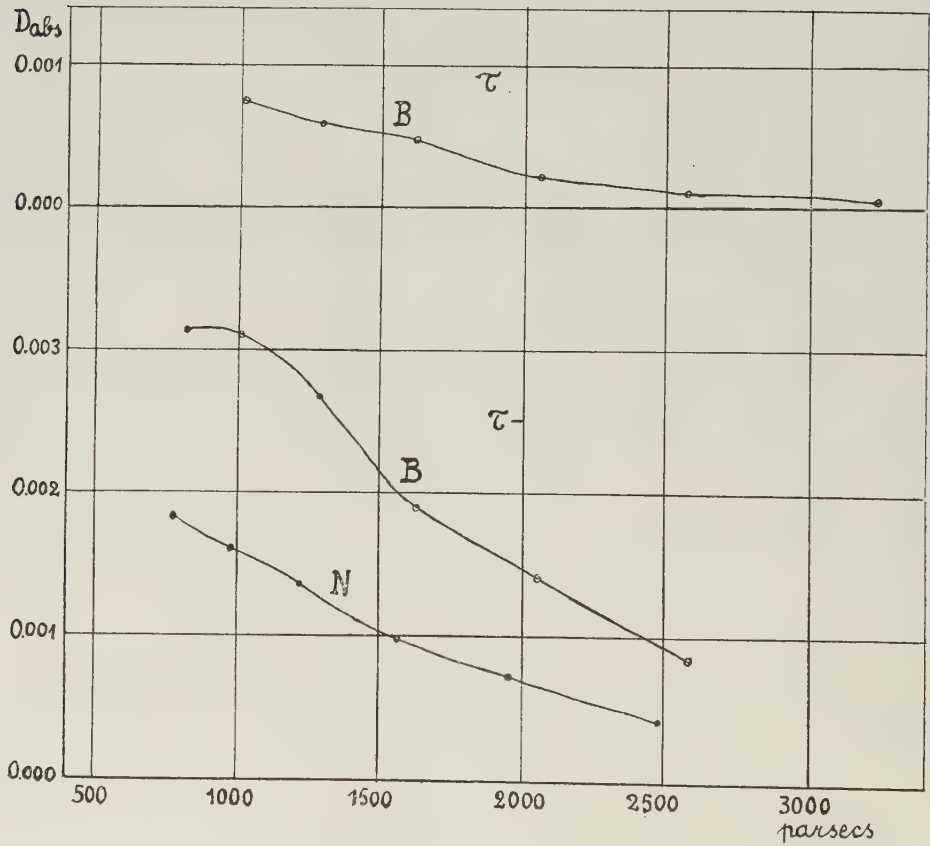


Fig. 17. Density curves for the τ and $\tau-$ stars in the regions B and N of Auriga.

of the τ and τ - stars in Auriga. These stars are so few in number in reg. *S* that it is hardly possible to draw any conclusions. This small number of stars belonging to the τ groups seems to be in harmony with our previous results as to the adjacent absorbing nebula in reg. *S*. I do not compute the space densities from these few stars.

Also in region *N* the number of τ stars is too small to admit of any computations. For the τ - stars in reg. *N* and for both groups τ in reg. *B* the calculated densities are given in Table 26, the corresponding curves in Fig. 17. They show a continuous density decrease outwards. The curves for regions *N* and *B* show the same run although the densities in the outer region are considerably smaller.

CHAPTER VII.

Comparison and Discussion of Results from all the Regions.

1. Surface density and intensity of galactic light.

In the Tables 9, 15, 20, and 24 the area density of stars of different luminosity classes was given for a number of regions. We shall investigate here the correlation between these area densities and the brightness of the Milky Way. Visual estimations of the brightness of the galactic zone from $+30^\circ$ to -30° galactic latitude have been performed by PANNEKOEK in his work »Die nördliche Milchstrasse».¹ His results were combined with those obtained by EASTON² to a mean image of the Milky Way, of which PANNEKOEK says in his memoir just cited: »Da diese Darstellung, obgleich weniger Einzelheiten der Struktur zeigend, die allgemeine Helligkeitsverteilung am Besten wiedergeben wird, ist sie überall zu benutzen, wo es sich um zahlenmässige Daten für die Helligkeit des Milchstrassenlichtes, z. B. bei Vergleichen mit Sternzählungen, handelt». I have used these numbers therefore when comparing with the area densities. They are to be found given on p. 92—99 of PANNEKOEK's work for each degree of galactic latitude from $+30^\circ$ to -30° and each degree of galactic longitude.

In Table 27 for the different regions investigated in this paper I give the approximate galactic coordinates (according to the coordinate system used by PANNEKOEK, namely gal. pole at RA $12^h 40^m$, $D + 30^\circ$), the corresponding brightness taken from PANNEKOEK's table, furthermore the surface density for the different luminosity groups for all stars and for those of mag. 10. The correlation coefficients computed from the numbers of Table 27 are given in Table 28, together with their probable errors. The correlation between the faint stars and the Milky Way's brightness is somewhat smaller for all groups than it is if all stars are combined. — I have repeatedly pointed out that the main difference between the bright and dark regions lies

¹ PANNEKOEK, Die nördliche Milchstrasse, Ann. van de Sterrewacht te Leiden, XI, 3 (1920).

² EASTON, La voie lactée dans l'hémisphère boréal (1893).

Table 27.

Brightness of the Milky Way and number of stars per square degree.

Region	Galactic		<i>Bright- ness:</i> PANNE- KOEK, EASTON	Number of stars per sq. degree										
	long.	lat.		All stars					Stars of mag. 9.6—10.5					
				τ	$\tau-$	σ	ρ	κ	τ	$\tau-$	σ	ρ	κ	
Cyg N_2	43°	+10°...12°	2.5	0.18	0.52	2.44	2.02	2.00	0.03	0.13	1.10	1.26	1.05	
» N_1	43	+ 3 ... 5	4.6	3.67	3.43	5.00	4.15	3.15	1.45	1.73	2.30	2.70	1.94	
» S_1	43	- 2 ... 0	2.1	0.56	0.76	3.47	3.37	2.54	0.28	0.52	1.32	2.05	1.63	
» S_2	43	- 6	3.0	0.20	0.37	2.54	1.47	1.44	0.03	0.09	1.09	1.12	0.92	
Cep Nb	70	+ 7	2.5	2.30	2.65	2.86	0.82	2.04	0.61	1.79	1.58	0.46	1.07	
» Nd	67	+ 3	2.0	1.6	0.97	1.28	2.81	1.12	1.53	0.56	0.92	1.73	0.61	0.82
	72	+ 3 ... 5	1.2											
» Sb	69	- 2 ... 0	4.7	2.59	3.83	7.56	2.44	2.02	1.76	2.59	4.92	1.45	1.04	
» Sd	70	- 5	3.0	0.52	1.55	5.28	2.07	1.40	0.21	1.04	2.75	1.24	0.93	
» S_1	70	-10	1.8	0.39	0.97	3.13	1.50	1.14	0.11	0.17	1.80	0.94	0.78	
Cas D	99	+ 3	1.6	2.0	1.07	1.21	2.62	1.26	1.28	0.68	0.87	1.45	0.75	0.87
	96	- 5	2.5											
» B	97	0	3.1	3.0	2.90	2.57	4.12	1.91	1.21	1.80	1.51	2.46	1.03	0.74
	98	- 4	2.8											
Aur N	133	+ 8	1.3	1.7	0.12	1.42	3.12	2.91	1.94	0.09	0.73	1.51	2.15	1.39
		0	2.1											
» B	133	+ 3	3.4	1.02	3.74	6.32	2.65	1.63	0.36	1.99	4.28	1.75	1.20	
» S	133	- 5	0.5	0.15	0.19	0.52	0.41	0.41	0.11	0.07	0.30	0.30	0.30	

Table 28.

Correlation coefficients computed from Table 27.

Class	All stars		Stars of mag. 10.	
τ	0.69	± 0.09	0.65	± 0.10
$\tau-$	.77	.07	.73	.08
σ	.84	.05	.75	.08
ϱ	.60	.12	.55	.13
κ	0.60	0.12	0.53	0.13

in the difference in the number of τ and $\tau-$ stars. The correlation for the τ stars is, however, *rather low*. It is to be observed that the variation in the number of τ stars in the different regions is, in many cases, considerably greater than the corresponding variation of the estimated brightness. For example, in Cygnus the variation of the intensity for regions N_2 and N_1 is $25 : 46 = 1 : 1.84$ while for the surface densities the variation is $18 : 367 = 1 : 20.4$,

more than 10 times as large, in Cepheus the variations for S_1 and Sb are 1:2.6 and 1:6.6. *A good correlation between the observed intensities of the Milky Way and the star-numbers is shown by the τ - and σ stars.* For the stars belonging to the ϱ and π groups there is only low correlation.

2. The space density in the different regions.

When comparing and discussing the run of the density curves in the different areas of the galactic zone we have to regard especially the regions where no obscuring matter can distort the results. We have, consequently, for great distances to consider the following regions in or near the galactic plane: In Cygnus, reg. N_1 , in Cepheus, reg. Sb , in Cassiopeia, reg. B , and in Auriga, reg. B . For moderate distances, below 800 parsecs, we may also consider the following regions near the galactic plane: Cyg S_1 , Cep Sd , Cas D , and Aur N . All these regions may be considered as representing the galactic plane as their galactic latitude never exceeds some few degrees.

In order to get a comparative survey of the general run of the density curves in the different regions, I give in Fig. 18 the curves for the relative density for the groups τ , σ , and ϱ , putting the density = 1 for $r = 500$. It is to be observed that *the curves for the τ groups are uncertain for distances below 800 à 1000 parsecs*, owing to the small number of stars falling within this distance interval.

The curves for Auriga deviate considerably from those of the other regions. They indicate a nearly constant star-density for distances below 1000 parsecs. Let us leave this region out of consideration; its influence will be pointed out later. For the other regions — Cyg, Cep, and Cas — we take simply the mean values of the D_{rel} for every 100 parsecs in each of the groups τ , σ , and ϱ . Then we get the numbers of Table 29. Thus they represent the run of the curves as the mean of three directions, including an

Table 29.

Mean values of the relative density from different regions.

r	$\tau, \tau-$	σ	ϱ	$\sigma-\varrho$
300	6	1.5	1.3	1.4
400	2.4	1.2	1.2	1.2
500	1.00	1.00	1.00	1.00
600	0.73	0.82	0.82	0.82
700	0.61	0.69	0.68	0.69
800	0.50	0.57	0.58	0.58
900	0.47	0.46	0.42	0.44
1000	0.46			
2000	0.20			

angle of 60° , from Cyg to Cas. We consider the distance interval below 800 parsecs, where the curves of all the three groups are known. It is found that the slope of the curve for the τ group, representing approximately the B stars, is much steeper than that for the other groups representing the $B8-A0$ stars. See Fig. 18. *This is, probably, a consequence of the strong concentration of bright B stars in the vicinity of the sun* pointed out especially by CHARLIER.¹ Now, as was remarked above, the run of the curves for the

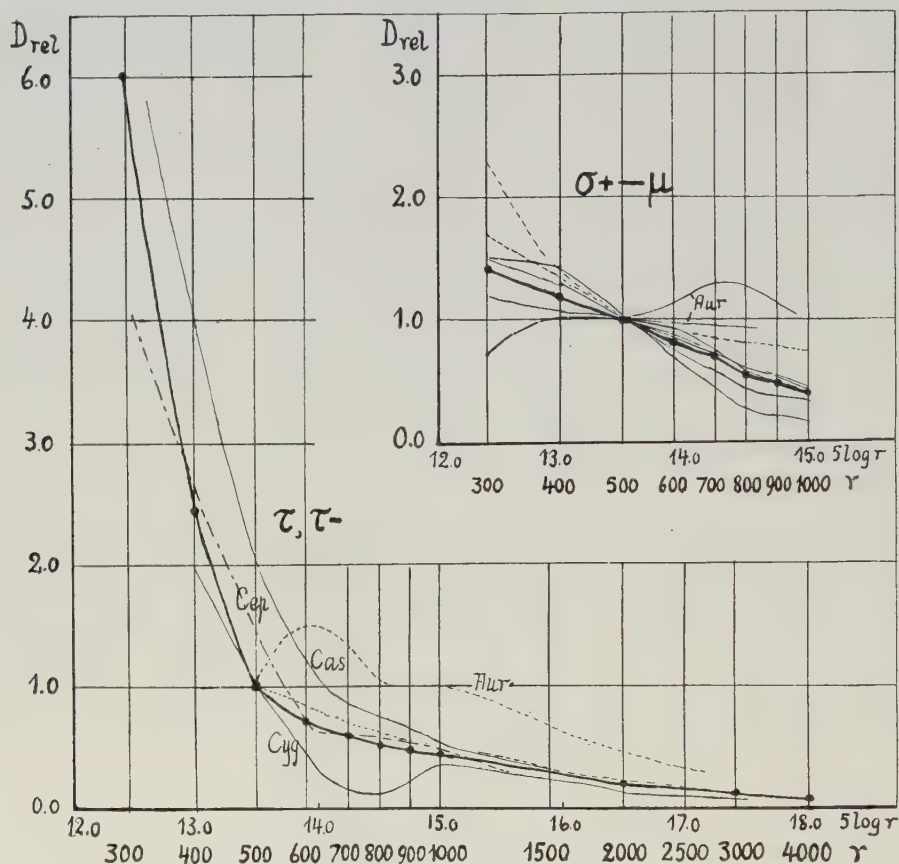


Fig. 18. Curves of relative density.

τ group for small distances is very uncertain. Therefore a closer examination of this curve and comparison with the density function of CHARLIER will hardly give any reliable results.

For great distances, 1000–4000 parsecs, the density curves of the τ group show a continuous and slow decrease outwards.

¹ CHARLIER, The distances and the distribution of the stars of the spectral type B, Nova Acta Reg. Soc. sc. Ups., IV, vol. 4, no. 7, Meddel. fr. Lunds astr. observ., II, 14 (1916). — On the galaxy of the B stars. Nova Acta etc., vol. extra ordinem edit. 1927, Meddel. fr. Lunds astr. observ., II, 14 (1926). — The motion and the distribution of the stars, Memoirs of the University of California, vol. 7 (1926).

The density curves of the *A* stars are reliable, as they are based on a large number of stars. *The A stars show no clustering.* The density only shows a continuous and slow decrease outwards.

The following remarks may be made: If the Auriga region had been included the decrease of density would have been slower for all the groups. — If the regions with neighbouring dark nebulae had been included the slope of the curves would, of course, have been steeper, consequently a clustering would have appeared also for the *A* stars. *The necessity for neglecting such regions of obscuration in discussions of the present nature is self-evident. They must contribute to give an impression of a sharply limited »local cluster».* As was just mentioned the curves for the *A* stars in the regions investigated here do not indicate any local agglomeration.

The existence or non-existence of such a »local cluster» as pointed out by CHARLIER, SHAPLEY¹ and others will not be discussed here as the material of the present investigation can hardly be used for any definitive conclusions on this subject. The assumption of a local cluster was previously considered necessary for the explanation of the observed motions of the stars. According to the theories of LINDBLAD², however, the observed motions in our neighbourhood of space are explained by the assumption of a general rotation of the Milky Way system around a distant centre. — The designation »local system» has recently been used by SEARES³ for a system of much greater dimensions, several thousand parsecs in diameter.

The space distribution of stars of different spectral classes in the Cygnus region of the Milky Way has been studied by MAXWELL.⁴ He has determined spectra for faint stars in some selected areas. For the stars of types *B* and *A* MAXWELL has employed the usual Harvard classes. Within the late types distinction was made between giants and dwarfs using, principally, the variation in the strength of the cyanogen band at λ 3883. For his computations MAXWELL has also used stars from the Henry Draper Catalogue and Extension. The material of *B* stars is rather scanty. The density curve shows a progressive decrease from 400 to 4000 parsecs. For the *A* stars (as also for the other spectral classes discussed by MAXWELL) the density is constant for distances below 400 parsecs and then continually decreasing. The decrease of density for the *B* stars is slower in my curves than in those of MAXWELL.

The space distribution of stars of different spectral types, brighter than mag. 8.25, has recently been studied by SHAIJN⁵ on the basis of the Draper

¹ SHAPLEY, Studies based on the colors and magnitudes in stellar clusters XII, *Astrophys. Journal*, 49, 311, Mount Wils. Contr., No. 157 (1919). — Spectral type B and the local stellar system, *Wash. Proceedings of Nat. Ac. of Sc.*, 5, 434 (1919).

² LINDBLAD, On the cause of the ellipsoidal distribution of stellar velocities, *Arkiv för Matem. astr. & fys.*, 20 A, No. 17, Meddel. från Astron. observ. Upsala, No. 26 (1927).

³ SEARES, Some structural features of the galactic system, *Astrophys. Journal*, 67, 123, Mount Wilson Contr., No. 347 (1927).

⁴ MAXWELL, The space distribution of the stars etc. *Lick Obs. Bull.*, No. 390 (1927).

⁵ SHAIJN, On the distribution in space of the stars of the Henry Draper Catalogue down to 8^m.25, *Astr. Nachr.*, No. 5546 (1928).

Catalogue. SHAIJN divided the sphere into 48 areas (according to CHARLIER) and the distribution was compared in the galactic areas ($0^\circ - \pm 34^\circ$) and non-galactic areas (34° —poles). A general decrease of density is pointed out. As to stars of spectral types *B9* and *A0* SHAIJN finds a clustering of stars at a distance of about 100 parsecs in low galactic latitudes. The non-uniform distribution of stars in galactic longitude for the galactic regions is remarked.

3. Equi-density lines.

We are now going to study the lines of equal density for the quadrant of the Milky Way included between Cygnus and Auriga. We use the results from the areas Cyg *N*₁, Cep *Sb*, Cas *B*, and Aur *B*. The distances for which we have equal density are given in Table 30, for each one of the classes τ , $\tau-$, and $\sigma+$ to μ . The lines of equal density based on the numbers of

Table 30.

Distances (in parsecs) for equal absolute density.

$D_{\text{abs.}}$	Cyg	Cep	Cas	Aur
	τ			
0.000125	4000	2300	3100	2450
0.00025	3000	1825	2100	2050
	$\tau-$			
	1600	1500	1300	1800
0.0016	1000	850	775	800
0.0032				
	$\sigma+$ to μ			
	700	675	450	400
0.08	510	400	300	290
0.12				

Table 30 are constructed in Fig. 19, where the x -axis points towards gal. longitude 0° . (The dotted curve in the figure is a smoothed curve.)

The lines of equal density for the τ stars indicate a lack of stars in the Cepheus direction. Excepting one of the $\tau-$ curves all the lines show that a certain density is reached at the greatest distance in the Cygnus direction, both for great and small distances.

According to modern views the sun's position in the big stellar system should be very excentric. The centre of the great system is to be found in the direction of galactic longitude 330° . The system should, therefore, among the regions examined here, be most elongated in the direction of Cygnus, while in Auriga (direction opposite to that of the centre) we ought to find

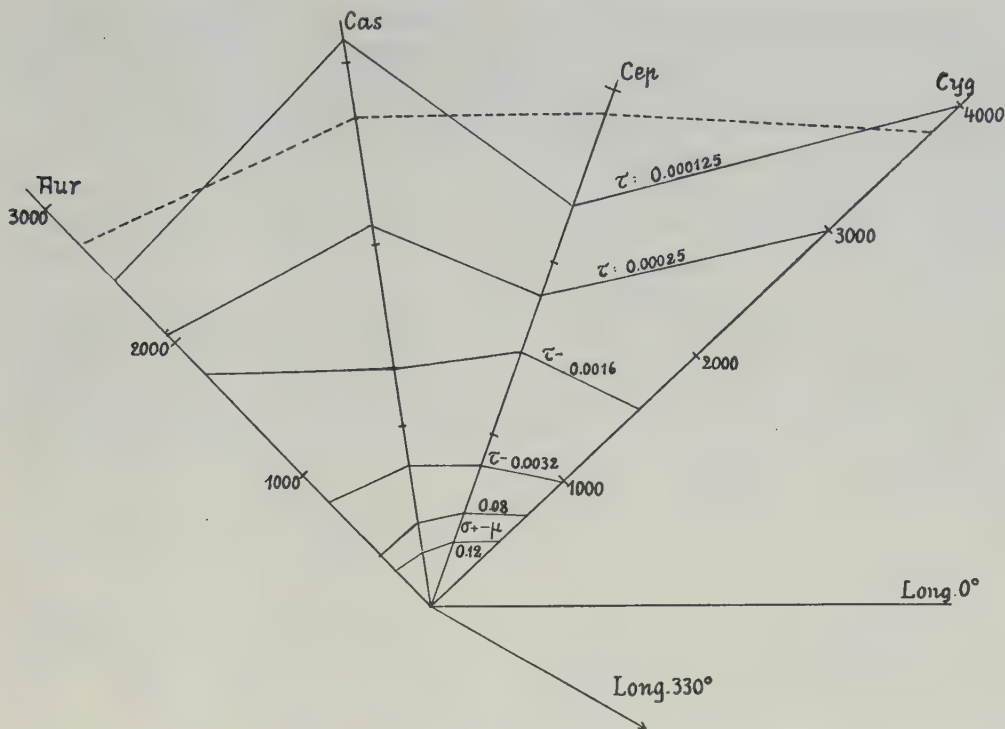


Fig. 19. Equi-density lines in the galactic plane.

the shortest way out of the system. This is in agreement with the curves obtained here, especially with the curves for the $\sigma + \mu$ stars and with those based on the τ stars. The deduction of the general run of the density curves in the galactic plane and of the distance to the centre of the big stellar system (assumed to be situated in gal. long. 330°) is a very delicate problem, as long as the density curves are known only for this quadrant of the galactic plane. It may be sufficient to say here that *the run of the density curves in this quadrant of the Milky Way seems to harmonize with the assumption of the excentric position of the sun in the big stellar system.* For definite conclusions it will be necessary to study the distribution of the stars also in other directions.

It will be of some interest to compare these results for the density curves in the galactic plane with those obtained by other investigators. KREIKEN¹ in his research on the distribution of the different spectral types along the Milky Way (on the basis of the material from the Henry Draper Catalogue) gives the distances of equal density for the *B* stars and the *A* stars. The Milky Way zone embraces the galactic latitudes -10° to $+10^\circ$ and the stars within this zone were combined from 30° to 30° in gal. longitude, so that the areas considered are rather large. In the Fig. 4, p. 996, of his paper KREIKEN gives the density curves for the *B* stars and *A* stars (the distances are small,

¹ KREIKEN, On the distribution of the different spectral types along the Milky Way, Month. Not., 85, 985 (1925).

hardly exceeding 200 parsecs). These curves show the same general run as my curves although the lack of stars in the direction of Auriga is more pronounced in KREIKEN's curves, owing to the fact that the large areas considered by him include also the regions of the dark nebulosities in Taurus. — SHAPLEY¹ arrived at analogous results through his star-counts in selected fields. — KREIKEN also, in a later paper², derived the density curve for all spectral types together: his Figure 7 in the paper last cited shows also the influence of the nebulosities in Taurus.

PANNEKOEK, in his memoir »Researches on the structure of the universe»³ gives on p. 104 the density curves for the space within some hundred parsecs from the sun. Although his research is to a great extent a study of details of the structure of the Milky Way, these density curves, as is remarked by PANNEKOEK on p. 103 of the cited memoir, are based on average values for great regions of 20° square. Thus these curves can represent the density distribution only in its largest features. Comparing the lines for the zone 0° to +20° with my curves we find that they are rather similar, showing the greatest extension of the system in the direction of Cygnus; also in Auriga these curves indicate a great extension of the system. This is, however, not the case with the curves for the zone 0° to -20°, where the curves are influenced by the Taurus nebulae. (PANNEKOEK's designation »local star-system» refers to the space within 1000 parsecs from our sun).

4. Comparison with regions at high galactic latitudes.

At the discussion on the Cygnus and Cepheus regions we had the opportunity of investigating the galactic concentration of some groups of stars, as those two regions included plates also at a galactic latitude of about 10°. In this paragraph an investigation of the space density of the stars of types $\varrho-\alpha$ in different galactic latitudes will be made through a comparison with the results obtained by LINDBLAD, PETERSSON, and MALMQUIST.

LINDBLAD⁴ has examined an area (of the Greenwich zone) at a gal. latitude of +47°, PETERSSON⁵ a region around the north celestial pole at a latitude of +28°. The A stars in those regions are all of types $\varrho-\alpha$.

In addition to these two regions an area around the north galactic pole may also be used. In a recent investigation⁶ MALMQUIST has determined

¹ SHAPLEY, On the spectral constitution of the nearer parts of the Milky Way, Harv. Circ., 240 (1922). Spectral class, apparent magnitude, and galactic position for stars of the Henry Draper Catalogue, Harv. Circ., 248 (1923).

² KREIKEN, On the centre of the local star system, Month. Not., vol. 86, 665 (1926).

³ PANNEKOEK, Researches on the structure of the universe etc., Publ. of the Astr. Inst. of the Univ. of Amsterdam, No. 1 (1924).

⁴ LINDBLAD, On the decrease of star density etc., Medd. fr. Astr. observ. Upsala, No. 14 (1926).

⁵ PETERSSON, The distribution of distances etc., Ibid., No. 29 (1927).

⁶ MALMQUIST, Investigations on the stars in high galactic latitudes I, Lunds Univ. Årsskr. avd. 2, bd 24 No. 1, Kungl. Fysiogr. sällsk. handl. 39, No. 1, Meddel. från Lunds astr. observ., II, 37 (1927).

magnitudes and colour indices for stars down to mag. 13—14 in a region near the galactic pole. According to his colour indices the number of white stars (that have colour indices within the limits $0.00 \leq c \leq 0.24$) is only 39 when the members of the Coma Berenices cluster are excluded. MALMQUIST has derived the space density from the 39 stars according to different methods. In order to get a direct comparison with the results from the other regions I have tried to compute the space density in the following manner. The *A* stars all belong, certainly, to the types ϱ — κ . Let us assume that those having the colour index within the limits $0.00 \leq c \leq 0.10$ belong to the ϱ group, those with the colour index within the limits $0.10 \leq c \leq 0.24$ to the κ group. According to MALMQUIST's catalogue there are 57 stars brighter than photographic magnitude 13.0 (except the Coma Berenices stars), having their colour indices within the limits required. They are distributed according to phot. mag. thus:

	ϱ, μ	κ —, κ
$m_{\text{ph.}} \leq 8.0$	7	4
$m_{\text{ph.}} > 8.0$	4	32.

From this it is clear that, probably, nearly all faint stars are κ stars while most of the bright ones belong to the ϱ group. We may then among the 39 stars used for statistical purposes discriminate, approximately, between the groups ϱ and κ . We assume the following numbers:

	ϱ, μ	κ —, κ
$m_{\text{ph.}} \leq 8.0$	6	3
$m_{\text{ph.}} > 8.0$	3	27.

Using MALMQUIST's Table XLI, p. 50, we may then derive the probable number of stars within intervals of photographic magnitude, belonging to the groups ϱ and κ . The absolute densities computed from these numbers are given in

Table 31.
Densities computed from MALMQUIST's stars.

<i>r</i> parsecs	<i>D</i> _{abs.}	MALMQUIST	
		Method <i>A</i>	Method <i>B</i>
100	0.300	0.108	
150	.200	.100	
200	.122	.087	
250	.060	.070	0.090
300	.035	.055	.070
350	.030	.039	.052
400	.026	.028	.040
450	0.022	0.021	0.030

Table 32.

Distances (r) and heights (H) for equal density.

$D_{\text{abs.}}$	Cyg S_2		Cyg S_1		Cyg N_1		Cyg N_2		$b = +28^\circ$		$b = +47^\circ$		Pole	
	r	H	r	H	r	H	r	H	r	H	r	H	r	H
0.40					320	14			138	65				
.35			275	12	345	15	220	34	141	66	100	73		
.30			330	14	390	17	250	39	152	71	117	86	100	100
.25			400	17	500	22	340	53	176	83	145	106	125	125
.20	200	31	480	21			390	61	220	103	174	127	150	150
.15	250	39							250	117	192	140	163	163
.10	350	55							290	136	217	159	225	225
0.05	500	78							430	202	275	201	260	260

Table 31. The densities found by MALMQUIST are also given. In the following comparison I will use the densities computed here. It is seen from the table that from 200 parsecs the densities computed according to MALMQUIST's method Ab and the procedure used here agree rather well.

The densities for the ϱ - α stars at the different galactic latitudes must now be compared with those in the Cygnus area. This region is not situated in the same gal. longitude as the regions of LINDBLAD and PETERSSON but it has the greatest extension from the galactic plane, and the stars of low luminosity are unaffected by obscuring nebulosity. In Table 32 the distances, and the heights over the galactic plane through the point of observation are given, where the same density is reached. The corresponding equi-density lines are drawn in Fig. 20. The lines between the two regions at 47° and 28° were already drawn by PETERSSON and discussed by him. He pointed out the inclination of the lines of great densities towards the galactic plane; for great heights over the plane, i.e. for small densities, the lines were found to be parallel with the galactic plane. It is of interest to find here that the comparison with the results from the Cygnus region confirms the inclination of the layers of equal density for great densities. The extension of a certain density layer in the direction of gal. latitude $2^\circ.5$ is thus three or four times as large, as in the direction of the pole, in our neighbourhood of space. It is to be observed that a comparison with one of the other galactic regions would cause a greater inclination of the density lines towards the galactic plane. — For small densities no conclusions can be drawn, as they do not appear in the Cygnus region within the distances considered. The supposed parallelism of the lines with the galactic plane is not supported, however, by the comparison with the pole region.

The heights over the galactic plane through the point of observation are small in the Cygnus region, owing to the low galactic latitude. — A comparison with results from the south galactic hemisphere would be of interest

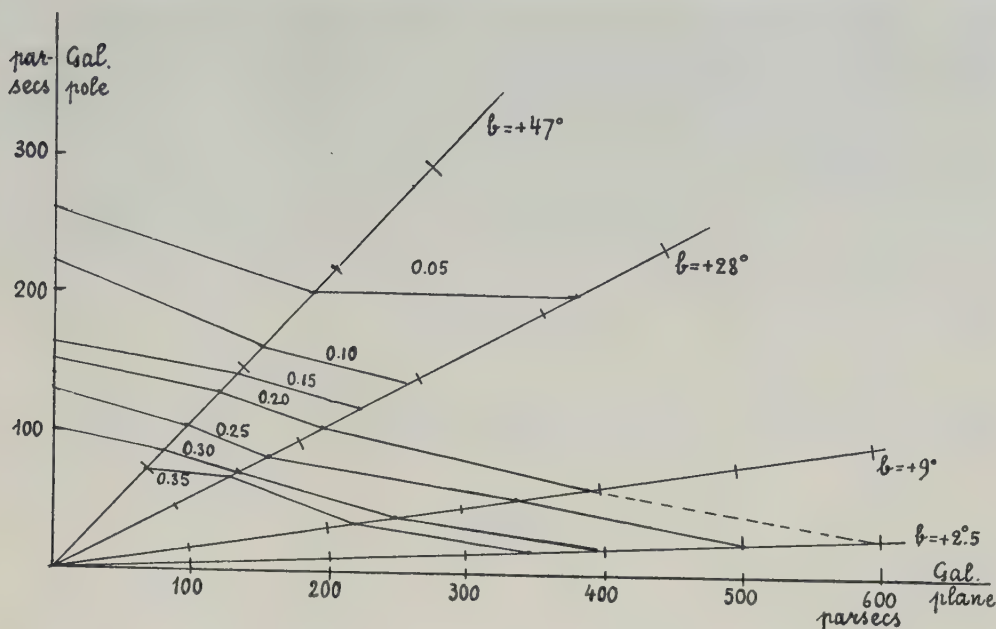


Fig. 20. Lines of equal density for the stars of types ρ — α . (The regions are *not* situated in the same gal. long.).

for the determination of the position of the sun, relative to the galactic plane. — The spectral classes under consideration here correspond, approximately, to the Harvard types A0—A3. The strong concentration to the galactic plane of these stars is evident from Fig. 20.

5. On the luminosity curve of the A stars.

For each sub-class of the Upsala classification we have, *à priori*, assumed that the absolute magnitudes are distributed according to a normal error curve. Consequently we have no reason to examine the luminosity curve for each group separately. But it may be of interest to investigate the luminosity curve for all the classes σ + to α together, which represent the B8—A3 stars.

Using the (m, r) -table for each luminosity class within each area investigated it is easy to count the number of stars of different absolute magnitudes within different intervals of distance. After that it will be possible to examine 1) if the luminosity curve for the spectral interval considered changes from one region to another, 2) if the curve changes with distance.

The areas used for this investigation are the following: in Cygnus, all the areas as no absorbing matter exists at small distances, in Cepheus, regions S and S_1 , in Cassiopeia, the whole region, in Auriga, the areas N and B . The regions N in Cepheus, and S in Auriga, are not used because of the absorbing nebulae at small distances. The number of stars was counted for $r < 325$ parsecs and for $325 < r < 500$ parsecs. I do not give here the results for

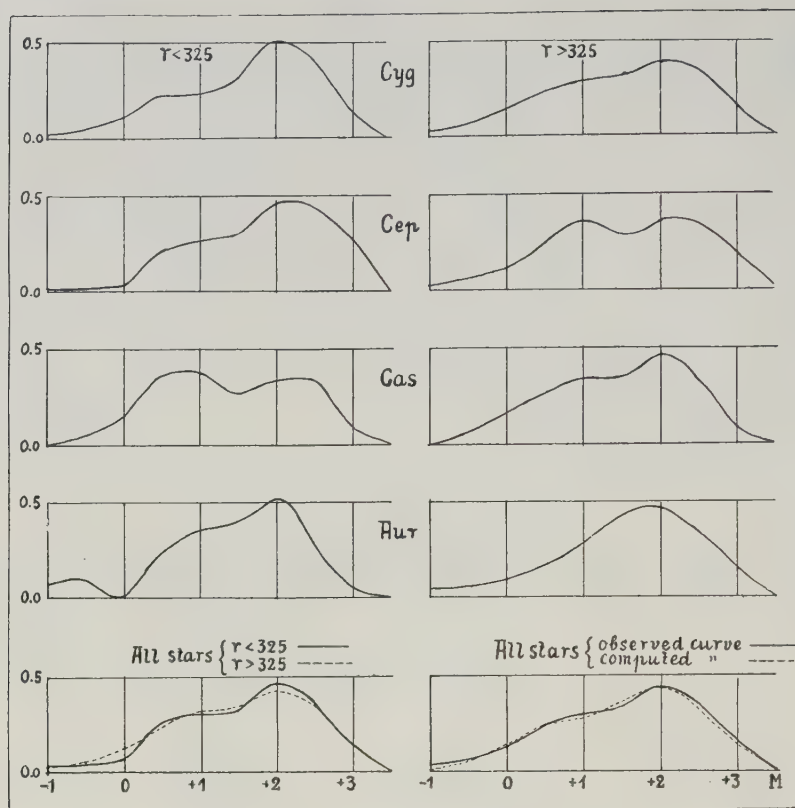
Fig. 21. Luminosity curves for stars of types $\sigma+$ to ξ (B8—A3).

Table 33.

The luminosity curve.

M	Cygnus		Cepheus		Cassiopeia		Auriga		All regions	
	$r < 325$	$r > 325$	$r < 325$	$r > 325$	$r < 325$	$r > 325$	$r < 325$	$r > 325$	$r < 325$	$r > 325$
-1.0	0.02	0.03	0.02	0.03	0.00	0.00	0.07	0.03	0.03	0.03
-0.5	.05	.07	.02	.07	.05	.05	.10	.05	.05	.06
0.0	.11	.15	.03	.11	.14	.16	.00	.09	.07	.13
+0.5	.22	.24	.22	.24	.37	.25	.24	.16	.26	.22
+1.0	.23	.29	.27	.36	.39	.33	.36	.28	.31	.32
+1.5	.32	.32	.29	.28	.26	.34	.40	.43	.32	.34
+2.0	.51	.39	.46	.36	.35	.45	.52	.47	.46	.42
+2.5	.40	.34	.43	.34	.35	.33	.26	.34	.36	.34
+3.0	0.13	0.15	0.26	0.20	0.09	0.08	0.05	0.14	0.13	0.14
Number of stars	164	294	58	109	57	95	42	91	321	589

each small area separately, but the results are combined for each one of the four regions in the Milky Way. The luminosity curves for these regions are given in Fig. 21. They are based on the numbers of Table 33. These numbers have been obtained from the directly counted star-numbers by multiplication with a factor, constant within each area and distance interval, in order to eliminate the difference in volume and density between the different areas. This factor was chosen so that

$$\int_{-\infty}^{+\infty} \varphi(M) dM = 1.$$

As the intervals of M were chosen = half a magnitude this means that each star-number (ordinate) $\varphi(M)$ was multiplied by the factor

$$1 : 0.5 \Sigma \varphi(M).$$

The curves have the same general appearance for all regions: a maximum at $M=2.0$ and an indication of a second maximum at $M=0.5-1.0$. This second maximum is, however, especially marked in Cassiopeia for $r < 325$ and in Cepheus for $r > 325$, while in Auriga for $r > 325$ no such maximum exists. Thus the relative number of stars forming the two maxima of the curve is somewhat different in one case than in the other.

The luminosity curve does not show any marked change with distance. This is most easily seen by combining all the curves for $r < 325$ and all those for $r > 325$. The two curves are almost identical as is seen from the figure; and we remark especially that the principal maximum occurs in both curves at $M=2.0$. It was noted by PETERSSON¹ that for his region (around the north celestial pole) the maximum was displaced with 0.3 mag. towards fainter magnitudes for greater distances. — Comparing our curves for the two distance intervals with those of PETERSSON we remark at once that 1) the relative number of stars forming the two maxima is different for the galactic plane and the region at high galactic latitude, 2) the principal maximum occurs for $M=2.0$ in the galactic plane, for $M=2.3-2.6$ in the other region. These two facts depend on the absence of stars belonging to the σ group in PETERSSON's region and the abundance of π stars.

MALMQUIST has examined the form of the luminosity curve for the white stars.² He has found that the curve has two pronounced maxima and may be considered as composed of two nearly normal curves with equal dispersion and with the mean values equal to $+0.5$ and $+2.3$, the modes (the maximum values of frequency) equal to $+0.6$ and $+2.2$. Do the results derived here agree with those of MALMQUIST?

¹ PETERSSON, Loc. cit., p. 58.

² MALMQUIST, A method of determining the arrangement in space of the stars, Kungl. Sv. Vet.-ak:s Handl., III, Bd 4, No. 2, Meddel. från Lunds astr. observ., II, 46 (1927) (especially Table XIX, p. 47).

Let us assume, in accordance with MALMQUIST, that the number of stars belonging to the first component of the luminosity curve is N_1 , that to the second N_2 . Then we shall have, if the luminosity curve is composed of two normal curves,

$$(N_1 + N_2) \varphi(M) = \frac{N_1}{\sigma_1 \sqrt{2\pi}} e^{-\frac{(M-M_1)^2}{2\sigma_1^2}} + \frac{N_2}{\sigma_2 \sqrt{2\pi}} e^{-\frac{(M-M_2)^2}{2\sigma_2^2}}.$$

It is easily found by means of tests that the observed luminosity curve for *all the regions together* is satisfied by the following values of the constants:

$$\begin{aligned} N_1 &= 0.58 & N_2 &= 1.42 \\ M_1 &= 0.5 & M_2 &= 2.0 \\ \sigma_1 &= 0.55 & \sigma_2 &= 0.65. \end{aligned}$$

The comparison between observed and computed values gives the following result:

M	-1.0	-0.5	0.0	0.5	1.0	1.5	2.0	2.5	3.0
$\varphi(M)$ obs.=	0.02	0.06	0.12	0.24	0.30	0.33	0.43	0.35	0.15
$\varphi(M)$ comp.=	0.00	0.04	0.14	0.24	0.27	0.36	0.43	0.32	0.13
Obs.—comp.=	+0.02	+0.02	-0.02	± 0.00	+0.03	-0.03	± 0.00	+0.03	+0.02

The comparison between the two curves, the observed one and the computed one, shows that the agreement is very good. The luminosity curve of the A stars is thus composed of two normal error curves.

The question now arises whether the constants of these error curves coincide with those derived by MALMQUIST. At first it is found that

$$\frac{N_1}{N_2} = \frac{58}{142} \sim \frac{4}{10},$$

in agreement with the statement of MALMQUIST that the proportion between the number of stars of the two components is $\frac{4}{9}$ in space.¹ But according to MALMQUIST the dispersion of each curve should be $= 0.45$, thus smaller than was found here. Finally we have here the difference

$$M_2 - M_1 = 1.5$$

between the mean values (or modes, as the curves are assumed to be normal). MALMQUIST gives the values 1.8 between the means, 1.6 between the modes. — His values referred to here are derived from von ZEIPPEL and LINDGREN's research of M 37², while for the other systems investigated — Auriga cloud,

¹ MALMQUIST, l. c., p. 42.

² V. ZEIPPEL and LINDGREN, Photometrische Untersuchungen der Sterngruppe Messier 37, Kungl. Sv. Vet.-ak:s Handl., Bd 61, No. 15 (1921).

Scutum cloud, NGC 752, Coma Berenices, »local system» — rather large deviations occur¹, although it seems probable that the luminosity curve should be the same as in *M* 37. In view of this it may be stated that *the results obtained here for the luminosity curve of the A stars agree, on the whole, with MALMQUIST'S results.*

In the open cluster *M* 36 the division of the white stars into two groups of different luminosity is very pronounced according to WALLENQUIST.² The two maxima of the luminosity curve are separated by 1.6 mag., the dispersion of each component is small.

Summary.

A general survey of the present research was given at the end of Chapter I. Here mainly the results of the computations in Chapters VI and VII will be summarized.

1. The regions in which spectra have been determined are situated in or near the galactic plane in Cygnus, Cepheus, Cassiopeia, and Auriga (Fig. 1). For the statistical treatment of the material each region was divided into small areas according to the structure of the Milky Way (Figs. 2, 7, 13, and 15).

2. In the present research only *B* and *A* stars are considered. The absolute magnitudes used are those determined previously at Upsala.

3. The distribution of the stars of different luminosity classes (for the designation of the classes see Ch. II) over intervals of photographic magnitudes (determined at Upsala, see Ch. III) is given in Tables 9, 15, 20, and 24. The surface densities are also given. These tables show the influence of dark nebulae and of galactic latitude upon the star-numbers and surface densities.

4. The space density (= number of stars per 1000 cubic parsecs) and the density curves are given in a number of tables and figures in Ch. VI.

5. Through studies of the space distribution and the star-numbers the distances of dark nebulae have been derived. The results are summarized here:

Region	Approximate coordinates of the nebula	Distance (parsecs)	Absorption (magnitudes)	Material, remarks
Cyg	$20^h 25^m + 35^\circ$	800	2	τ , and τ - stars
Cep	21 50 + 58	370	0.9	σ +; σ , σ -; and ϱ , μ stars
»	21 45 + 57	800	1.5	τ , and τ - stars
Cas	$\left\{ \begin{array}{l} 1\ 50\ +\ 63 \\ 1\ 30\ +\ 56 \end{array} \right\}$	900	1	τ , and τ - stars. (The existence of this nebula is doubtful)
Aur	4 45 + 36	126	1.8	σ +; σ , σ -; ϱ , μ ; and κ - stars

¹ See also MALMQUIST, loc. cit., Lund Meddel. II, 37, pp. 51 and 52.

² WALLENQUIST, Colours and magnitudes in the open cluster Messier 36, Kungl. Sv. Vet.-ak:s Handl., III, Bd 4, No. 8, Meddel. från Astr. observ. Upsala, No. 36 (1927).

6. The Cygnus cloud is discussed in Ch. VI, A, § 2. Its distance is proposed as being 1100 parsecs.

7. The concentration of the white stars to the galactic plane is evident from a study in the Cyg and Cep regions (Figs. 6 and 12) and also from a comparison with regions at high galactic latitudes (Fig. 20).

8. The *A* stars show no clustering at small distances. The density decreases slowly and continuously outwards (Ch. VII, § 2, Fig. 18).

9. The equi-density lines in the galactic plane show that a certain density is reached at the greatest distance in the direction of Cygnus (Fig. 19). The run of the density lines seems to harmonize with the assumption of the excentric position of the sun in the big stellar system.

10. The luminosity curve of the *A* stars has the same general appearance in all regions investigated and does not show any marked change with distance. It can be considered as composed of two normal error curves (Ch. VII, § 5, Fig. 21).

The General Catalogue.

The catalogue is composed of two parts.

Part I contains those stars which have been found in the Bonn Durchmusterung.

Part II embraces the stars not found in the B.D.

The successive columns of the catalogue contain the following data:

In *Part I* the *1st column* contains the B.D. number.

The *2nd column*, gives the apparent photographic magnitude on the International scale, as determined at Upsala.

The *3rd column* gives the spectral type and the luminosity class from my determinations. In some cases, for the groups τ to σ only the luminosity type is given. This means that the Harvard types of the star found from two plates did not agree (e.g., B from one plate, Ao from the other).

In the *4th column* the Harvard spectrum according to the Henry Draper Catalogue or Extension is given.

The *5th column* contains the distance of the star derived from the apparent magnitude in the 2nd column, and the mean absolute magnitudes of Chapter III B (p. 24). These distances have been calculated in order to give a general survey of the approximate distances reached by the stars of the different luminosity classes. *They have, of course, not been used directly for the derivation of the star-densities (see Ch. IV).* For those stars which, according to Chapter VI, are situated behind dark nebulae, the distances are not given, as they would be wrong when computed from the apparent magnitude of column 2.

In the *6th column* the area, in which the star is situated, is given. For the designation and situation of the areas, see Figs. 2, 7, 13, and 15. This column is not filled in for every star: all stars coming between two stars for which the area is given also belong to this same area (example: all the stars $43^{\circ} 3264$ — 3384 belong to the area N_2 of Cygnus). An asterisk (*) in this column refers to the remarks.

In *Part II* the *1st column* contains a current number.

The *2nd* and *3rd columns* contain the right ascension and declination of the star referred to the equinox 1900.0. The coordinates have been deter-

mined from measurements on the spectrum plates in relation to stars with known coordinates.

The *columns 4—8* of this *Part II* contain the same data as the columns 2—6 of Part I.

In this second part of the catalogue no stars fainter than the magnitude 10.7 have been included, unless they were classified on two plates in perfect accordance.

Part I contains 3790 stars, Part II, 529.

PART I.

C y g n u s.

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
43°						41°						40°					
3264	9.9	A2 κ		316	N_2	3345	9.1	A2 κ	A3	219	N_2	3745	9.0	A2 κ	A	209	N_2
3269	10.5	A0 μ		794		3352	7.4	A0 σ	B9	263		3763	9.8	A2 κ			302
3277	8.8	A0 κ —	A0	302		3353	9.3	A0 τ —		1585		3765	9.8	A2 κ —			380
3280	9.7	A2 σ		759		3354	8.8	A0 σ +	A0	692		3776	9.0	A2 κ —	A0		263
3282	8.0	A0 κ —	A2	209		3355	10.2	A0 ρ		724		3790	10.6	A2 κ —			550
3290	6.3	A0 σ +	A0	219		3362	10.5	A0 μ		794		3791	9.4	A0 μ			479
3319	7.7	A0 σ +	B8	417		3375	9.8	B τ —		1995		3793	8.8	A2 κ	A3	151	
3331	7.8	B τ —	B9	794		3382	10.5	A3 κ		380		3800	7.4	A0 ρ	A0	200	
3335	10.5	A0 μ		794		3389	9.3	A2 κ —		302		3801	7.8	A0 σ	A0	316	
3355	8.3	A2 κ —	A0	191		3394	9.1	A0 τ —		1445		3802	8.9	A3 κ —			251
3358	8.0	A0 σ	B8	347		3395	9.9	A2 κ		316		3806	10.7	A0 κ —			724
3361	9.5	A2 κ —		331		3396	10.6	A3 κ		398		3812	8.4	B8 τ —	A0	1047	
3370	9.8	A3 κ —		380		3397	7.0	A0 σ	B9	219		3815	9.2	A0 σ —			603
3377	9.5	A2 κ —		331		3398	6.5	A0 σ —	A0	174		3824	7.5	B τ	B2	1445	
3384	9.9	A0 σ		832	N_2	3400	10.8	τ —		3162		3843	10.4	A0 σ	A0	1047	
						3404	11.1	A0 σ —		1445		3844	9.4	A2 κ	A0	251	
42°						3411	10.1	A2 κ		347		3846	8.4	A0 σ +	A0	575	
3334	10.3	A0 ρ		759	N_2	3412	7.4	A0 σ	A0	263		3852	9.0	A2 μ	A2	398	
3336	9.1	A0 σ +		794		3418	9.6	A2 κ		275		3853	10.7	A0 σ	A0	1202	
3342	9.8	A3 κ		275		3442	8.7	A0 μ	A2	347		3855	9.5	A2 κ —	A2	331	
3345	9.6	A2 κ		275		3444	9.9	A3 κ —	A	398		3856	6.5	A0 σ —	A0	174	
3350	9.5	A2 κ —		331		3446	9.7	A0 ρ	A0	575		3860	10.1	A0 μ	A2	661	
3356	9.8	A0 ρ		603		3451	7.8	A0 σ +	B9	437		3861	10.4	A2 κ —	A2	501	
3359	8.5	A2 κ —	A3	209		3459	10.4	A0 σ —		1047		3870	7.4	B τ —	B8	661	
3360	9.9	A2 κ		316		3461	10.3	A0 μ		724		3872	10.6	A2 κ	A5	437	
3363	10.5	A2 κ —		525		3462	10.4	A0 σ		1047		3878	9.7	A0 ρ	A2	575	
3364	8.1	A0 σ —	A0	363		3465	10.4	A0 σ		1047		3887	9.6	A0 σ	A0	724	
3375	10.7	A0 ρ		912		3468	9.2	A0 σ —		603		3893	10.1	A0 ρ	A2	692	
3380	10.5	A0 σ		1096		3479	10.6	τ —		2884		3902	5.4	B τ	B2	550*	
3381	10.4	A3 κ		363		3482	9.9	A2 μ	A2	603		3904	9.6	A0 ρ	A0	550	
3386	5.1	A0 σ	A2	91		3484	9.9	A3 κ	A0	288		3909	9.2	A2 κ —	A2	288	
3389	10.7	A2 κ —		575		3485	8.6	A2 μ	A0	331		3912	7.5	B τ —	B9	692	
3406	10.1	A2 κ		347		3486	9.0	A0 σ +	A0	759		3915	8.8	A0 σ —	A0	501	
3413	5.0	B τ —	B8	219		3496	10.7	A0 σ +		1660		3916	9.3	A3 κ	A2	219	
3416	10.4	A2 κ		398		3501	10.1	A0 ρ	A0	692		3917	10.4	A0 ρ	A0	794	
3423	9.8	A2 κ —		380		3529	10.2	A0 σ +	B8	1318		3919	10.4	A0 ρ	A2	794	
3425	8.3	A0 σ	B8	398		3531	10.4	A2 κ	A3	398		3922	8.6	A0 σ +	A	631	
3433	10.2	A0 σ —		955		3543	7.9	A0 μ	A0	240		3925	10.6	A0 ρ	A2	871	
3439	10.5	A2 κ —		525		3550	8.7	A0 σ +		661		3931	6.9	B τ —	B3	525	
3441	9.8	A2 κ —		380		3569	7.7	B τ	B3	1585		3933	7.8	A3 κ —	A2	151	
3442	8.7	A0 σ	A0	479		3575	7.2	A0 ρ	A0	182		3937	9.7	A2 μ	A3	550	
3456	9.7	A2 κ —		363		3580	10.7	A0 μ		871		3938	10.5	A2 κ —	A3	525	
3460	9.5	A0 μ		501		3595	10.1	A0 σ +	A2	1259*		3940	10.9	A0 ρ	A0	1000	
3462	10.7	A2 κ		457		3598	10.2	A0 μ	A2	692		3941	9.1	A2 ρ	A0	437	
3463	7.6	A0 κ	A0	110		3611	9.5	A0 τ —	A0	1738	N_2	3943	10.3	A0 ρ	A7	759	
3475	8.7	A3 κ	A3	166								3944	10.4	A0 ρ	A	794	
3481	9.8	A2 κ —		380		40°						3945	9.1	B8 σ +	A2	794	
3484	8.2	A0 σ +	A0	525		3714	9.3	A0 σ —		631	N_2	3948	7.3	B τ	B3	1318	
3500	10.5	A0 σ		1096		3719	9.7	A2 κ —		363		3949	9.3	B τ —	B8	1585	
3508	8.2	A0 σ +	B9	525		3721	9.5	A0 μ		501		3951	9.9	A0 σ	A2	832	
3509	10.6	A2 κ —		550	N_2	3722	9.0	A0 σ +		759	N_2	3953	10.4	A0 μ	A3	759	N_2

B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
40°						39°						39°					
3954	9.7	B τ —	B8	1905	N_2	3900	9.2	A0 σ	B8	603	N_2	4081	9.6	A0 σ —		724	N_1
3959	8.7	A0 κ —	A2	288	N_2	3903	9.1	A0 μ	A2	417		4082	7.7	B τ	B3	1585	
3960	8.7	A0 σ —	A0	479	N_1	3905	7.3	A0 τ —	B9	631		4084	10.1	A0 σ —	A0	912	
3961	10.5	A0 μ	B9	794		3908	7.4	A2 μ	A2	191		4089	9.9	A0 σ	B9	832	
3962	9.7	A0 ρ	A2	575		3909	9.4	A3 κ —	A2	316		4091	9.9	A0 μ	A2	603	
3966	10.4	A0 τ	F0	5500		3911	9.0	A2 μ	B9	398		4094	9.5	A0 σ	A0	692	
3968	10.4	A2 κ	A3	398		3913	10.2	A0 μ	A	692		4095	10.6	A0 μ	A0	832	
3974	10.3	A0 ρ	A5	759		3915	9.9	A3 κ —	A5	398		4096	8.1	B τ	B3	1905	
3978	9.7	A2 κ	A3	288		3916	9.8	A0 μ	A0	575		4097	8.8	A0 σ	A0	501	
3979	9.7	A3 κ —	A2	363		3917	10.3	A0 μ	A0	724		4100	10.4	τ	B3	5495	
3982	7.2	B8 σ +	A0	331		3919	9.4	A2 κ	A7	251		4104	9.5	A2 ρ	A2	525	
3984	9.2	A0 μ	A0	437		3921	9.0	A2 κ —	A2	263		4106	9.5	A0 σ —	B9	692	
3986	9.7	A0 σ +	A0	1047		3924	10.4	A0 μ	A0	759		4111	10.1	A3 κ	A3	316	
3990	8.2	A0 μ	A0	275		3926	9.1	A0 σ		575		4112	9.6	A2 ρ	A2	550	
3995	10.3	A0 σ	A2	1000		3927	10.6	A0 σ —	A0	1148		4113	7.7	A0 σ	A0	302	
3996	10.6	A0 κ —	F0	692		3930	9.7	A0 σ —	A2	759		4115	6.4	A0 τ —	A0	417	
3998	7.8	A0 ρ	B9	240		3933	9.0	A0 ρ	A0	417		4118	8.8	A0 ρ	A0	380	
4002	9.6	A0 ρ	A3	550		3935	8.8	A0 σ +		692		4118	9.6	A0 μ		525	
4003	9.1	A0 τ —	B3	1445		3937	9.9	A0 σ +	A2	1148		4120	9.7	A0 σ —	A0	759	
4005	9.9	A2 σ +	A5	1148		3945	8.6	τ	B8	2400		4121	9.1	A0 σ —	B9	575	
4008	9.0	A0 μ		398		3949	11.0	A0 τ —	B9	3467		4122	9.3	A0 σ +	B5	871	
4014	9.9	A0 μ	A0	603		3952	8.5	A0 σ —	A2	437		4124	8.8	A0 σ —	A	501	
4015	8.0	A0 τ	B8	1820		3955	9.8	A0 σ	A0	794	N_2	4125	8.6	A3 κ —	A0	219	
4018	10.2	A2 κ —	A7	457		3962	10.1	A2 σ	B9	912	N_1	4126	8.8	B τ —	B3	1260	
4031	10.1	A0 ρ	A2	692		3964	9.8	A2 ρ	B9	603		4127	8.7	A0 σ —	A2	479	
4036	8.8	A0 ρ	A0	380		3966	9.4	A2 κ —	A2	316		4130	8.8	B τ	B	2630	
4038	9.8	A2 κ —	A0	380		3968	5.1	B τ —	B3	229		4132	9.8	τ —	B3	1995	
4043	8.1	A0 σ —	A0	363	N_1	3970	10.2	A0 ρ	A3	724		4134	10.5	A0 μ	A0	794	
						3979	10.1	A0 σ +	A2	1259		4137	10.1	τ —	B3	2290	
						3983	8.8	A0 ρ	A	380		4138	8.9	A0 τ —	B5	1318	
						3984	9.2	τ —	B3	1514		4140	8.9	A0 σ +	B8	724	
						3987	10.5	A0 ρ	A3	832		4144	9.5	A0 σ —	B9	692	
						3990	8.1	A0 σ —	A0	363		4146	9.9	A2 κ	F0	316	
						3995	9.3	A0 σ +	B5	871		4150	9.4	A0 μ	A5	479	N_1
						3998	9.2	A0 σ —	B8	603							
						4003	8.8	A3 κ	A	174		38°					
						4007	7.8	τ —	A0	794		3614	10.3	A0 σ		1000	N_2
						4011	8.8	A0 τ —	B8	1259		3650	6.6	A0 κ —	A0	110	
						4012	10.2	A0 σ	B8	955		3654	9.8	A0 ρ		603	
						4014	10.2	A0 σ	A2	955		3665	9.7	B τ —		1905	
						4017	7.6	A2 κ —	A0	138		3670	10.4	A0 σ		1047	
						4018	10.4	A0 τ	B3	5500		3673	10.4	A3 κ		363	
						4021	10.1	A0 ρ	A0	692		3679	9.7	A2 κ —		363	
						4023	10.2	A0 τ —	B3	2400		3696	8.8	A0 σ —	A0	501	
						4026	10.8	A2 κ	F2	479		3710	8.5	A0 ρ	A3	331	
						4028	8.7	A0 ρ	A0	363		3713	9.7	A0 μ	A0	550	
						4031	9.6	B τ	B	3800		3724	10.4	A0 μ	A0	759	
						4033	8.3	B τ	B	2090		3727	10.1	A0 σ +	A	1260	
						4036	9.6	A0 μ	A2	525		3732	9.6	A0 σ —	A	724	
						4039	9.4	A3 κ —	A5	316		3740	10.8	A0 μ	A0	912	
						4043	10.1	A3 κ	A5	316		3745	9.6	A0 σ +	A0	1000	
						4049	8.4	τ	B2	2190		3746	9.6	A0 σ	A0	724	
						4052	9.3	A0 μ	B9	457		3749	9.7	A2 κ —	A2	363	
						4054	7.1	B τ —	B8	575		3751	10.4	A0 σ +	B9	1445	
						4059	9.5	τ —	B2	1738		3754	10.2	A0 μ	A2	692	
						4067	9.4	A0 σ —	B8	661		3758	5.4	B8 σ +	B9	145	
						4072	10.4	A2 μ	B8	759		3760	8.5	A0 μ	A2	316	
						4074	10.3	A0 σ +	B8	1380		3761	9.0	A0 σ —		550	
						4075	7.0	A0 σ +	B9	302		3762	10.4	A2 κ	A3	398	
						4078	10.4	A0 μ	A2	759		3763	9.6	τ	B2	3800	
						4080	8.9	A0 ρ	B9	398	N_1	3767	9.3	A0 ρ		479	N_2

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
38°						38°						37°					
3770	9.5	A2κ—	A5	331	N_2	3963	7.3	A3κ	A2	87	N_1	3627	10.3	A0σ+	A0	1380	N_2
3773	8.3	Bτ—		1000		3964	9.7	A0σ+	B8	1047		3628	9.5	A2κ—	A3	331	
3776	10.4	A0μ	A5	759		3965	9.6	Bτ—	B3	1820		3630	9.9	Bτ—	B3	2090	
3781	10.3	A3κ—	A3	479		3968	10.1	τ	B5	4786		3633	10.3	A0σ+	A2	1380	
3782	8.9	A0μ		380		3971	7.9	A0σ	A0	331		3638	9.5	A0σ—	A0	692	
3791	9.3	A0σ	A0	631		3973	9.6	A0σ+	A	1000		3639	8.8	A2κ—	A2	240	
3794	9.5	A0σ+		955		3977	6.0	A0σ—	A0	138		3645	9.2	A0μ	A0	437	
3795	10.6	A0σ	A0	1148		3978	10.1	A0μ	A3	661		3646	10.4	A0σ—	A0	1047	
3797	9.4	A2κ—	A3	316	N_2	3980	8.6	Bτ	B	2400		3647	9.2	A2κ	A2	229	
3802	9.1	A2κ—	A2	275	N_1	3986	10.5	A0μ	A0	794		3652	8.7	A2σ	A2	479	N_2
3804	10.5	A0μ	A0	794		3987	9.8	A0τ—		1995		3654	9.8	A2κ—	A2	380	N_1
3809	8.0	B8τ—	B9	871		3988	10.3	σ+	B	1380		3657	9.4	A2κ—	A2	316	
3812	10.2	A2κ—	A3	457		3989	9.8	A0σ		794		3660	9.3	A0σ+	B8	871	
3817	4.6	τ—	B3	182		3991	8.9	σ+	B5	724		3666	10.2	A0σ+	B8	1318	
3820	10.4	A0σ—	B9	1047		3992	10.5	A0μ	A0	794		3667	9.9	A0τ—	B8	2090	
3823	9.2	A0σ—	B8	603		3997	8.9	τ—	B8	1318		3668	10.8	A0μ	A0	912	
3824	10.5	A2κ—	F0	525		3999	9.8	A0τ—	B8	1995		3669	10.5	A2κ—	A0	525	
3826	9.4	A0ρ	B8	501		4000	9.5	A0τ	B0	3630		3675	10.2	A3κ	A3	331	
3828	10.7	A0ρ	A3	912		4002	9.8	A0τ	B	4170		3678	10.5	A0σ	A3	1096	
3831	9.4	A2κ—	A3	316		4006	7.7	Bτ	B2	1585		3680	10.3	A0μ	A5	724	
3832	6.6	A0σ	A2	182		4012	9.1	A0τ	B	3020		3682	10.4	A0σ—	B9	1047	
3841	10.6	A0σ+	A2	1585		4014	10.3	A0σ	A5	1000		3683	9.7	A2μ	A2	550	
3842	9.8	A2κ	A0	302		4015	9.6	A0ρ	A7	550		3685	9.3	A2κ—	A	302	
3845	9.8	A3κ	A3	275		4016	10.3	τ	B	5248		3691	9.2	A0ρ	A	457	
3846	10.2	τ—	B5	2400		4019	8.2	A0σ—	A0	380		3696	10.5	A3κ		380*	
3848	9.3	τ—	B5	1585		4021	6.2	A0σ—	A0	151		3697	10.4	A0σ	A0	1047	
3852	10.4	τ	A0	5495		4025	10.4	τ	B	5495		3703	6.1	τ—	B5	363	
3854	9.9	A2κ—	A2	398		4026	8.8	A0σ+	B9	692		3711	9.9	A0τ—	B5	2090	
3855	9.9	A0μ	A0	603		4031	10.3	τ—	B2	2512		3723	7.9	Bτ	B5	1738	
3862	7.2	A0σ—	A0	240		4032	8.2	Bτ—	B8	955		3725	9.6	Bτ—		1820	
3865	8.6	A0σ—	A2	457		4033	10.1	A0μ	A0	661		3726	9.9	A0ρ	B9	631	
3869	7.5	σ+	A0	380		4034	10.3	A2τ	B3	5248		3727	7.7	B8σ—	A0	302	
3871	8.5	A2μ	A2	316		4036	9.4	A0τ	B	3467	N_1	3728	9.7	A2κ—	A5	363	
3883	9.7	A0σ+	B9	1047		4037	9.1	A2μ	A0	417	S_1	3730	10.2	A0σ+	A2	1318	
3885	10.5	A0μ	A7	794		4040	10.4	τ—	F0			3731	9.7	A0τ—	A8	1905	
3886	10.4	A0σ—	A2	1047		4043	9.5	A0τ	B			3732	9.6	A0ρ	A2	550	
3887	10.4	A2κ—	A3	501		4052	8.7	A0ρ	A0	363		3733	9.7	A0μ	B9	550	
3889	10.5	A0σ+	B8	1514		4073	10.3	A2τ—	A2			3734	9.3	Bτ—	B8	1585	
3890	10.4	A0ρ	A2	794		4114	8.3	B8σ+	A0	550		3735	7.2	A3κ—	A2	115	
3892	9.9	A2κ—	A2	398		4121	8.5	A0σ	A0	437		3736	9.7	τ—	A	1905	
3898	9.2	A2κ	A3	229		4129	10.4	A0μ		759	S_1	3737	10.5	A0σ	A7	1096	
3902	10.1	A3κ	A0	316								3738	10.3	A0ρ	A0	759	
3905	8.1	B8τ—	A0	912		37°						3740	8.5	A2ρ	A2	331	
3907	9.7	A0μ	A0	550		3574	9.7	A0μ	A0	550	N_2	3741	8.4	A0μ	A2	302	
3909	8.9	A0σ+	A	724		3579	9.8	A0σ—		794		3742	8.8	A0σ	A	501	
3910	9.3	A2μ	A5	457		3581	10.2	A0σ	A0	955		3743	9.7	A0σ—	A0	759	
3913	8.3	A2κ—	A0	191		3582	6.7	A0σ+	B8	263		3745	10.9	A0σ+	A	1820	
3914	9.8	A2κ—	A2	380		3583	9.5	A0μ	B9	501		3746	9.9	A0τ—	B8	2090	
3920	10.6	A0μ	A	832		3584	7.6	A3κ—	A2	138		3748	8.9	B8τ—	A	1318	
3922	9.6	A0σ	A0	724		3585	8.8	B8τ—	B5	1259		3749	8.9	A0σ	A	525	
3924	10.2	A2κ—	A2	457		3597	9.3	A0ρ	A2	479		3751	10.7	A0σ		1202*	
3933	9.7	A2σ	A2	759		3598	8.1	A2κ—	A2	174		3752	8.2	A0σ	A0	380	
3934	10.7	A2κ—	A0	575		3601	9.6	A0σ	A2	724		3754	8.8	A0μ	A0	363*	
3941	8.1	A0σ+	A0	501		3605	10.2	A3κ	A5	331		3755	10.8	A0ρ		955	
3942	8.5	σ+	A	603		3606	9.6	A0σ—		724		3759	9.0	A0μ	A	398	
3952	8.6	A0σ+	A2	631		3609	7.9	A0σ	A0	331		3765	9.6	A0μ	A0	525	
3954	10.5	A0τ		5754*		3611	10.3	A0μ	A2	724		3767	10.8	A0σ	F2	1259	
3956	7.5	Bτ	B2	1445		3613	9.1	A0σ	A0	575		3768	10.2	τ	B2	5012	
3958	8.9	A0τ	B	2754		3615	9.3	Bτ	B5	3310		3771	9.5	A0σ	B9	692	
3959	10.5	A0σ+	B9	1514		3625	10.5	A0μ	F0	794	N_2	3772	8.3	A0σ	A0	398	
3961	10.3	A0μ	A0	724	N_1							3774	8.5	A0ρ	A0	331	N_1

B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
37°						37°						36°					
3776	9.8	A0 τ —	B5	1995	N_1	3897	7.4	B8 σ	B9	263	N_1	3773	10.5	A0 σ	A2	1096	N_1
3780	10.6	A0 σ +	B8	1585		3898	9.6	A0 τ	B		S_1	3774	9.8	A0 σ —	A0	794	
3783	9.0	B τ	B	2884		3900	8.6	A0 μ	A0	331		3775	9.4	A2 κ —	A2	316	
3784	7.7	B τ —	A0	759		3901	10.6	A0 τ —	B			3776	9.3	A2 κ	A3	240	
3785	9.4	A0 τ —	B2	1660		3904	8.9	A0 ρ	A	398		3780	10.3	σ +	A0	1380	
3788	10.4	A0 μ	A3	759		3905	10.8	A0 τ —	B8			3782	10.4	A0 τ —	F0	2630	
3790	9.8	A0 τ —	A	1995		3910	10.2	τ	B			3784	9.3	τ —	B3	1585	
3791	9.9	A0 σ —	A0	832		3913	9.8	τ —	B			3794	8.6	A0 σ	A	457	
3793	9.8	A0 τ —	B2	4170		3915	10.3	A0 κ —	A0	603		3795	10.7	A0 σ +	A	1660	
3795	10.8	A0 τ		6600		3916	5.5	B τ	B3	575		3801	10.6	A0 τ —	B8	2884	
3796	10.6	A0 σ +	B	1585	*	3918	8.4	A0 ρ	A0	316		3802	10.2	A0 μ	A2	692	
3801	10.3	A0 μ	A2	724		3919	9.4	A0 σ	B9	661		3804	10.3	A0 σ —	A3	1000	
3804	8.4	B τ —	B	1047		3921	9.2	A2 κ	A2	229		3806	4.8	B τ —	B3	200	
3805	9.0	A0 σ +	B9	759		3922	8.0	B8 μ	A0	251		3810	10.8	A0 σ —	A0	1260	
3806	10.8	A0 τ —	B8p	3162	*	3923	8.8	A0 σ +	A	692		3811	10.2	A0 τ —	B3	2400	
3808	9.3	A0 ρ	A0	479		3924	10.1	B8 σ +	B9			3815	9.8	A0 σ	A0	794	
3809	9.1	τ —	B8	1445		3925	10.1	A0 μ	A0	661		3816	6.3	B τ —	B9	398	
3811	8.9	B8 τ —	B8	1318		3928	10.5	A0 μ				3822	8.9	A0 σ	A0	525	
3813	10.2	A2 κ —	A2	457		3932	9.7	A0 μ		550		3824	10.4	A3 κ	A7	363	
3816	8.9	B τ —	B8	1318		3933	9.7	A0 μ		550		3825	9.9	A0 τ	B3	4365	
3817	9.8	A3 κ	A5	275		3934	9.1	A0 σ —	A2	575		3826	10.7	A0 ρ	A0	912	
3818	10.6	A0 σ	A	1148		3935	9.1	A0 τ —	A3			3829	10.3	A2 μ	A2	724	
3819	9.6	A0 τ	B8	3800		3939	10.5	A0 μ				3840	9.4	A2 κ —	A5	316	
3824	9.6	B τ	B2	3800		3941	5.5	A2 κ —	A0	52	*	3841	8.2	B τ	B2	1995	
3825	10.1	A0 τ	B5	4786		3942	10.3	A2 κ —		479		3844	9.9	A0 ρ	A0	631	
3828	9.1	B τ	B5	3020		3944	8.0	B σ +	A0	479	*	3845	10.6	A0 τ		6026	
3834	8.8	A0 ρ	A2	380		3947	10.1	A0 τ —				3848	8.1	A0 σ —	A0	363	
3835	9.8	τ	B2	4170		3948	9.1	A0 μ		417		3851	9.6	A2 κ —	A3	347	
3837	9.7	τ	B0	3980		3949	9.6	A2 κ —		347		3855	10.5	A0 σ +	A0	1514	
3838	10.1	τ	B0	4786		3951	9.3	A0 σ		631		3856	10.8	A0 ρ	A5	955	
3839	9.5	A2 κ —	A2	331		3952	7.9	B σ +	B9	457		3863	10.3	A0 τ —	B8	2512	
3840	9.5	A0 μ	A0	501			8.4	B σ +		575		3864	10.4	A0 τ —	B3	2630	
3842	9.3	A3 κ	A7	219		3953	8.3	B8 σ +	A0	550		3869	10.3	A0 ρ	A7	759	
3843	9.7	A0 μ	A0	550		3955	8.7	τ —	A5	*		3870	10.8	A0 σ	A2	1260	
3844	8.9	τ	B0	2754		3961	10.3	A0 μ		724		3872	10.5	A2 σ	B9	1096	
3847	9.9	A0 μ	A0	603		3965	9.9	A0 μ		603		3873	9.0	A2 κ —	A2	263	
3849	9.2	A0 ρ	A2	457		3966	10.2	A0 μ		692		3879	10.3	A0 σ	B8	1000	
3852	9.7	A0 μ	A0	550		3967	10.5	A0 ρ				3880	7.1	A2 κ —	A0	110	
3855	9.3	A0 μ	B8	457		3968	11.0	A0 μ				3882	10.5	B τ		5754	
3856	10.5	A0 τ —	B	2754		3969	10.4	A0 σ				3884	10.4	A0 σ +	A0	1445	
3858	9.7	A0 σ	B8	759		3984	10.2	A2 κ —		457	S_1	3887	9.5	A2 κ —	A5	331	
3859	10.2	τ		5012								3891	8.9	A0 σ +	A5	724	
3860	8.4	B τ	B	2188		36°						3894	10.2	A0 σ —	A0	955	
3861	9.5	B τ —	B	1738		3683	10.3	A0 μ	A0	724	N_2	3896	7.5	B τ	B3	1445	
3862	9.6	τ		3800		3687	10.1	A0 σ	A	912		3897	9.4	A0 ρ	B8	501	
3864	8.7	A3 κ	A3	166		3692	8.3	A0 μ	A0	288		3900	8.6	B τ	B	2400	
3866	7.9	B τ	B	1738		3694	8.7	A0 σ —	A0	479		3903	10.4	A2 σ	A0	1047	
3867	7.3	B τ	B2	1318		3696	10.2	A0 μ	A0	692		3906	8.9	B τ	B	2754	
3871	5.3	B τ	B1p	525	*	3705	10.2	A0 μ	A0	692		3907	4.6	B τ	B2p	380	*
3873	8.9	B8 τ —	B3	1318		3707	10.1	A2 μ	A0	661		3911	9.7	A2 κ —	A3	363	
3877	10.3	τ		5250	*	3709	7.8	A0 σ	A2	316		3914	9.3	A0 τ	R0	3310	
3878	8.8	τ	B	2630		3712	10.1	A0 σ +		1260		3916	7.6	A0 σ —	A0	288	
3879	7.6	B τ	B1	1514		3715	8.5	A0 σ +	A0	603		3917	9.3	A0 κ —	A0	380	
3881	9.0	B τ	Bp	2884		3717	10.1	A0 μ	B9	661		3918	9.3	σ +	B9	871	
3883	8.6	A0 σ —	A0	457		3721	9.5	A0 μ	A0	501		3921	10.1	A0 σ	B9	912	
3889	8.5	τ —	A2	1096		3729	10.3	A0 μ	A2	724		3922	9.5	A0 ρ	A0	525	
3890	9.4	τ	B	3467		3752	10.2	A0 ρ	B9	724	N_3	3924	10.5	A0 ρ	B9	832	
3891	10.3	τ —	B8	2512		3759	8.9	A0 σ —	A2	525	N_1	3925	9.7	A0 τ —	B5	1905	
3892	7.7	τ —	B8	759		3768	10.2	B τ —	B8	2400		3927	9.3	τ —	B	1585	
3893	10.3	A0 μ	A0	912		3769	9.9	A0 ρ	A3	631		3928	10.2	A0 σ +	B8	1318	
3894	8.8	τ	B	2630	N_1	3772	9.8	A0 μ	A2	575	N_1	3932	9.9	τ	A5	4365	* N_1

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
36°						36°						35°					
3933	8.2	A0μ	A0	275	N_1	4125	10.2	A0μ		692	S_1	3993	9.6	Bτ	B	3802	N_1
3934	10.5	A0τ	A2	5754	*	4144	9.1	A2κ—	A2	275		3994	7.1	Bτ—	B3p	575	
3937	8.5	A2κ—	A0	209		4145	9.5	τ			S_1	3995	7.9	Bτ	B2	1738	
3940	10.6	A0ρ	A2	871								3997	10.1	A0τ—	B3	2290	
3943	8.4	A3κ	A3	145		35°						3998	9.4	τ	B	3467	
3945	8.9	Bτ	B3	2754		3876	7.6	B8σ+	B9	398	N_1	4000	9.0	A0σ	B9	550	
3946	8.5	Bτ	B	2290		3878	5.7	Bτ—	B3	302		4001	7.8	A2τ—	Ob	794	
3947	9.0	τ	B	2884		3880	9.3	A0τ—	B9	1585		4004	9.0	Bτ	B	2884	
3948	9.9	Bτ—	B3	2090		3881	8.5	A0σ	A0	437		4005	10.5	A2κ	A0	417	
3949	6.3	A0σ+	A2	219		3884	9.3	A0ρ	B9	479		4006	7.9	Bτ	B3	1738	
3951	10.5	A0ρ	A0	832		3889	7.4	A0σ	B9	263		4008	9.3	τ—		1585	
3954	9.0	A0σ+	B9	759		3891	9.6	A0τ—	B3	1820		4009	10.1	τ—		2290	
3955	5.0	A0ρ	A0	66		3892	9.5	A0μ	A2	501		4010	9.9	A0σ+	A	1148	
3958	7.3	Bτ	Oe5	1318		3895	6.9	A0σ—	A0	209		4011	9.6	A2κ—	B9	347	
3961	9.4	τ	B3	3467		3896	10.1	A0σ—	B8	912		4012	9.8	A0σ	A2	794	
3962	8.0	A0ρ	A0	263		3898	8.0	A0σ	B9	347		4016	9.4	A0σ—	B9	661	
3964	8.7	Bτ—	B5	1202		3899	9.3	Bτ	B	3310		4017	10.5	A2κ—		525	
3971	10.3	A2κ—	A0	479		3906	9.6	A2κ	A7	275		4018	10.4	σ+	A	1445	
3972	10.3	τ—	B3	2512		3910	10.6	A2κ—	A0	550		4019	9.6	A0τ—	B5	1820	
3976	9.5	A0σ+	A0	955		3912	10.1	A0μ	B8	661		4021	10.1	A2τ—	B3	2290	
3978	6.4	τ—	B5	417		3913	10.5	A0μ	A0	794		4022	9.7	A0μ	A2	550	
3981	9.7	A2κ—	A2	363		3915	10.3	τ—	B8	2512		4024	9.5	A2κ—	A3	331	
3982	10.1	A2κ—	A5	437		3922	10.4	A0ρ	A0	794		4025	10.5	A0σ	A0	1096	
3989	10.8	A0μ	A7	912		3924	10.3	τ	B	5248		4026	7.1	Bτ	B3	1202	N_1
3991	9.8	Bτ	B	4170		3929	9.8	Bτ		4170		4030	10.6	A0τ—	A5	457	S_1
3996	8.7	A0μ	A2	347		3930	6.6	Bτ	Oe	955		4032	8.6	A0σ—	A0	457	
3998	5.4	A0μ	A0	76		3932	9.7	Bτ	B3	3980		4034	10.2	A0σ			
4001	10.3	Bτ—	B	2512		3933	9.4	A3κ—	A2	316		4035	10.1	A3κ	A7	316	
4004	10.7	A0τ	B	6310		3935	9.9	A3κ	A5	288		4040	9.0	A0μ	A	398	
4008	6.4	A0σ	A0	166		3936	9.6	Bτ	B3	3800		4045	9.8	A0κ—	A2	479	
4009	8.5	A2κ	A0	166		3937	9.7	A0ρ	A0	575		4047	7.1	A0σ—	B9	229	
4010	9.5	A2κ—	A3	331	N_1	3938	9.8	A3κ	A3	275		4048	7.7	A0σ	A0	302	
4012	10.5	A2κ—	A0	525	S_1	3939	9.3	A0σ—	A2	631		4051	10.5	A2κ—	A0	525	
4014	10.4	A2κ—	A5	501	*	3943	9.6	A0σ+	A3	1000		4059	7.4	σ+	B9	363	
4016	10.8	τ—	A			3946	9.6	B8σ+	B8	1000		4060	10.4	A0μ	A0		
4018	10.1	A3κ	F0	316		3948	8.9	Bτ		2754		4062	9.5	τ	B		
4019	9.4	A3κ	F0	229		3949	7.9	Bτ	B	1738	*	4067	10.7	τ—	B		
4022	10.9	A0τ—	B			3950	9.0	Bτ	B	2884		4070	10.4	A0μ	A0		
4027	8.8	A3κ	F0	174		3952	7.5	A0τ	B	1445		4073	9.7	A3σ+	F0		
4030	9.8	A3κ	A7	275		3953	7.0	Bτ	Op	1148		4077	11.0	A0μ			
4033	10.4	A0σ+	B9			3955	7.3	τ		1318		4082	9.1	A0σ+	A3		
4042	10.8	A0μ	A0			3960	9.7	A0τ—	A	1905		4085	9.4	A0σ	B9	661	
4045	9.9	A0μ	A2	603		3961	10.1	Bτ	B8	4785		4097	9.8	A0ρ	A	479	
4046	10.1	A3κ	A5	316		3964	8.4	Bτ	B2	2188		4104	9.2	B8τ—	B8		
4049	9.3	Bτ—			*	3966	8.2	Bτ	B5	1995	*	4107	10.6	A2κ—		550	
4050	10.4	A0τ	B			3967	9.5	Bτ	B2	3630		4110	10.4	A0σ+			
4051	6.9	B8σ+	B9	288		3968	8.9	A0σ—	A0	525		4111	10.3	A0ρ		550	
4056	10.5	τ—	B8			3969	8.8	τ—	B3	1260		4112	9.7	A2μ		417	
4066	9.6	Bτ—				3970	7.1	Bτ	B0	1202		4115	8.4	σ—	A0	525	
4068	8.8	A2μ	A0	363		3973	9.4	A0σ+	B9	912		4120	9.6	A0μ		437	
4071	9.4	A0ρ		501		3974	9.5	A0σ+	A0	955		4123	9.2	A0μ			
4072	8.2	Bσ+	A0	525		3975	9.4	A2κ—	A2	316		4134	10.1	A2σ		603	
4073	9.5	A3κ		240		3977	9.3	A0ρ	A0	479		4135	9.9	A0μ			
4084	9.3	A2σ+	F2			3980	10.5	A2κ—	A0	525		4136	9.9	A2σ+			
4086	9.3	A0σ—	A0	631		3982	9.6	A0σ—	B8	724		4141	6.1	A0τ—	A0	363	*
4088	9.7	A0ρ		575		3983	9.1	Bτ—	B3	1445		4144	9.7	A2μ		550	
4090	10.3	A2κ		380		3984	10.8	A0σ+	A	1738		4145	10.4	A0σ—			
4095	8.0	Bτ	B5			3987	8.4	Bτ	B2	2188		4154	10.7	A0μ			
4102	10.2	A0μ		692		3988	8.7	A0σ—	A0	479		4155	10.5	A0σ			
4113	8.1	A0σ+	B9	501		3990	9.3	A3κ	F0	219		4158	9.2	A0σ+			
4121	9.9	A2σ			S_1	3992	9.7	τ—		1905	N_1	4161	9.7	A0ρ		575	S_1

B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
35°						34°						34°					
4163	9.1	A2 κ	F2	219	S_1	3929	10.3	A0 τ	B		S_1	4127	6.4	B8 τ —	B3	417	S_2
4164	10.3	A2 σ +				3932	8.6	σ +	A0	631		4132	9.3	A2 κ —		302	
4166	10.2	σ —				3934	8.4	σ +	A2	575		4135	9.7	A0 σ +		1047	
4168	11.0	A0 σ				3937	9.1	A2 κ —	A	275		4140	10.3	A0 τ —		2512	
4169	10.2	A2 κ —		457		3940	9.9	A2 μ	A0	603		4143	8.8	A0 σ		501	
4173	8.9	A2 κ —	A0	251		3941	10.2	A0 μ	B9	692		4145	10.4	σ +		1445	
4175	9.7	A2 κ —		363		3946	9.9	A2 κ	A2	316		4163	10.6	A0 μ		832	
4177	10.1	A2 κ		347		3950	8.7	A0 σ	A2	479		4165	10.1	A0 σ		912	
4180	9.7	A0 ρ		575		3951	9.9	B8 σ +	B9			4168	10.4	A0 σ		1047	
4181	10.4	A0 σ —				3952	10.5	τ	B			4170	10.3	A0 σ —		1000	
4187	9.3	A2 μ		457		3953	8.9	A0 σ +	A0	724		4172	10.3	A3 κ		347	
4188	8.7	A2 κ —	A2	229		3958	10.6	A0 σ	A0			4176	10.1	A0 μ		661	
4189	10.8	A0 μ				3960	10.5	A0 μ	A3			4184	7.2	B τ	B2	1259*	
4191	9.5	A0 μ		501		3962	10.5	A0 μ	A2			4196	7.8	B8 σ	B9	316	S_2
4197	8.2	A0 σ	A2	380		3964	10.8	A0 σ +	F0			33°					
4207	10.4	A3 κ		363		3968	8.6	A0 ρ	B9	347		3769	9.9	A3 κ	A3	288	S_1
4214	10.2	A3 κ		331		3971	8.8	A0 ρ	A5	380		3772	10.2	A0 μ	A2	692	
4217	7.8	B σ +	B9	437		3974	9.5	A0 μ	A0	501		3775	8.8	A0 σ	A	501	
4220	9.8	A0 κ —		479		3978	7.7	A0 σ +	B9	417		3776	9.2	A0 μ	B9	437	
4225	9.5	A3 κ —		331		3983	9.5	A0 σ	B9	692		3778	8.0	A0 σ —	A0	347	
4227	9.8	A2 κ —		380		3985	10.2	A2 κ —	A5	457		3780	8.1	A0 σ +	A0	501	
4230	9.5	A0 μ		501	S_1	3988	10.8	A2 κ —	A0	603		3790	9.2	B8 σ —	A0	603	
4231	8.3	A0 σ	A0	398	S_2	3990	9.1	A0 μ	A5	417		3791	9.4	A2 κ —	A2	316	
4232	7.8	A0 σ +	A0	437		3992	10.7	A0 τ —	B3			3800	9.1	A0 μ	B9	417	
4240	8.9	A0 μ	A2	380		3995	6.7	A2 κ —	A0	91		3802	7.8	B8 σ +	A0	437	
4243	9.2	A3 κ		209		3998	9.5	B σ	B9	692		3804	10.3	A2 κ —	F0	479	
4245	9.7	A0 σ +		1047		3999	10.1	A2 μ	A2	661		3805	10.4	B τ	A3		
4253	9.6	A0 μ		525		4003	9.9	A2 κ —		398		3806	8.9	A0 σ	A2	525	
4254	10.9	A2 κ —		631		4005	9.7	A0 σ +				3807	8.2	A0 μ	A2	275	
4258	9.3	A0 τ		3310		4007	8.9	A0 σ —	A0	525		3809	9.2	A0 σ	A0	603	
4272	8.8	A0 τ —		1259	S_2	4008	8.9	A3 κ	A2	182		3812	10.2	A2 κ	A2	363	
34°						4010	9.4	A0 μ		479		3813	9.3	A0 μ	A0	457	
3834	10.4	A0 σ +	A3	1445	—	4013	9.6	A0 τ —				3814	10.8	A0 σ	A0		
3842	9.9	A0 μ	A2	603		4014	9.3	A3 κ —	A	302		3817	8.6	A0 σ	A2	457	
3847	7.4	B τ —	A0	661		4016	8.8	A2 κ —	A	240		3833	8.4	A0 σ —	A0	417	
3849	9.7	A2 κ —	A2	363		4025	8.6	A0 σ —	A0	457		3835	7.9	A0 σ +	A0	457	
3850	9.4	B τ	B2	3467		4028	9.8	σ +				3837	7.8	B8 τ —	B9		
3852	10.2	A0 μ	A2	692		4033	10.4	A0 ρ		794		3839	10.7	A0 σ	A0		
3854	10.1	A0 σ +	B9	1259		4040	10.3	A2 μ		724		3840	10.3	A0 σ	A0		
3861	9.5	A2 μ	A0	501		4042	10.4	A0 σ —				3844	9.3	A2 μ	A0	457	
3863	10.1	B τ —	B5	2290		4052	10.2	A3 κ —		457		3847	10.3	A0 μ	A0	724	
3866	7.8	A0 σ —	A0	316		4053	10.3	A0 σ +				3850	9.1	A2 κ —	A	275	
3871	8.4	B τ	B3	2188		4056	—	{A0 σ } {A0 μ }	A2	*		3852	10.4	A0 σ —	A0		
3874	8.6	B τ	B	2400		4059	9.3	A0 σ		631		3853	9.7	A0 σ	B9		
3876	8.7	A0 ρ	A2	363		4062	9.7	A2 κ —		363		3856	10.3	A0 μ	A0	724	
3877	9.5	A0 τ	B3	3630		4072	10.1	A0 τ —				3859	9.7	A0 σ —	A0		
3879	10.3	A0 σ +	A2	1380		4073	9.7	A2 κ —		363		3860	9.7	A0 ρ	A2	575	
3882	7.8	A0 σ +	A0	437		4074	9.0	A0 μ	A0	398		3861	10.3	A0 μ	A0	724	
3885	9.3	A0 σ —	A0	631	—	4076	9.9	A0 ρ		631		3862	8.7	A3 κ	A	166	
3889	9.8	B τ —	B8		S_1	4077	10.1	A0 σ —				3863	9.7	A0 ρ	B8	575	
3900	9.7	A2 κ —	A3	363		4080	10.5	A3 κ		380		3868	10.3	A2 κ —	A3	479	
3902	9.2	A0 ρ	B9	457		4081	6.4	A0 σ +	B8	229		3873	8.3	A0 σ —	A0	398	
3903	10.6	A0 τ —	A3			4085	9.3	A2 μ		457		3880	10.4	A0 μ	A2		
3909	9.4	A0 μ	A0	479		4091	8.0	A0 μ	A0	251		3881	10.3	A0 ρ	B9		
3914	9.8	τ —	B8			4093	10.4	A0 σ				3885	8.2	A0 σ	A2	380	
3916	8.5	A0 μ	A0	316		4095	8.5	A0 σ —	A0	437		3888	10.2	A0 σ	A0		
3918	9.4	A0 ρ	A0	501		4103	9.0	A0 σ +				3890	8.1	A0 σ +	A0	501	
3920	8.8	A0 τ	B			4106	10.3	A2 κ —		479	S_1	3893	9.7	A0 μ		550	
3921	10.2	B τ —	B9			4119	10.2	A2 μ		692	S_2	3894	8.1	A0 σ —	A2	363	
3926	10.3	A0 μ	A2	724	S_1	4124	8.1	A2 κ —	A2	174	S_2	3896	9.6	A2 κ —		347	S_1

B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
33°						32°						31°					
3897	9.2 A0μ		A0	437	S_1	3832	9.6 A0ρ			550	S_1	4198	10.1 A0μ			661	S_2
3902	9.8 A0σ					3847	8.2 A0σ+		A3	525		4199	9.8 A2μ			575	
3907	9.1 A0μ			417		3862	7.2 Bτ—		B3	603		4204	8.1 Bτ		B3	1905	
3911	10.8 A2μ			724		3868	9.8 A2μ			575		4206	8.8 σ+			692	
3914	6.9 A0σ—		B9	209		3872	9.1 A0μ			417		4208	10.5 A0ρ			832	
3920	8.6 A0σ		A0	457		3877	9.7 A2κ—			363		4209	10.9 A0σ+			1820	
3921	9.2 A2μ			437		3879	9.6 A3κ—			347	S_1	4217	7.2 σ+		B9	331	
3928	10.3 A0ρ					3884	10.2 A0σ—			955	S_2	4218	9.0 Bτ			2884	
3932	8.7 A2κ—		A0	229		3887	10.2 A3κ			331		4219	10.2 A2μ			692	
3934	10.1 A2κ			347		3891	9.9 A2κ—			398		4220	7.4 A0σ		A0	263	
3935	9.4 A2κ—			316		3893	9.7 A0μ			550		4221	8.2 A2κ—		A0	182	
3941	10.6 A2μ					3895	9.6 A0ρ			550		4222	8.0 A3κ—		A2	166	
3942	9.6 A3κ			251		3903	8.4 A0σ		B9	417		4224	9.4 A0σ			661	
3944	8.5 A3κ—		A2	209		3904	9.4 σ+			912		4225	8.7 A0σ		A0	479	
3947	10.3 A2κ—			479		3909	10.1 A0μ			661		4226	10.4 A3κ			363	
3950	10.2 A3κ			331		3921	10.5 A0σ			1096		4231	10.4 A0ρ			794	
3956	10.5 A0ρ					3923	9.4 σ+			912		4239	10.5 A0σ—			1096	
3958	8.1 σ+		A0p	501		3928	9.0 A0ρ			417		4242	10.1 A0μ			661	
3961	10.4 A0κ—			631		3931	10.5 A2κ—			525		4248	9.5 Bσ			692	
3964	8.9 A2μ		A0	380		3934	10.4 A0μ			759		4256	9.2 A0σ+			832	
3966	9.0 A0σ		B9	550		3936	8.3 A2κ—		A0	191		4267	7.8 A2κ—		A2	151	
3972	10.2 A0ρ			724		3936	10.1 A3κ			316		4271	9.1 A2κ—		A0	275	
3981	8.6 A0σ—		A2	457		3944	10.1 A0σ—			912		4279	8.6 Bσ+		A2	631	
3982	10.3 A0ρ				S_1	3951	9.8 A3κ—			380		4283	9.6 A0σ			724	S_2
3984	10.4 A0μ			759	S_2	3952	10.4 A0μ			759							
3987	8.3 A2κ—		A3	191		3957	9.9 A0τ—			2090		30°					
3988	10.8 A0μ			912		3964	9.0 A0σ—			550		4050	9.0 B8σ+			759	S_2
3996	9.6 A0σ+			1000		3968	9.0 A2μ			398		4051	9.8 A3κ			275	
4003	7.5 A0σ		A0	275		3974	6.3 Bτ—		B5	398	S_2	4064	9.9 A0μ			603	
4004	7.0 A0σ+		A0	302								4082	10.3 A2ρ			759	
4006	10.3 A0σ+			1380		31°					S_1	4084	10.3 A0ρ			759	
4009	7.5 A0σ—		A0	275		4083	10.7 A0σ+					4085	10.5 A2κ—			525	
4012	10.4 A0σ—			1047		4084	9.6 A0σ			724		4086	9.6 A0σ+			1000	
4016	10.3 A3κ—			479		4086	10.9 A0μ					4092	9.8 A0μ			575	
4019	9.2 A0μ			437		4092	9.0 A0σ+					4097	9.5 τ			3630	
4020	10.2 A3κ—			457		4097	10.3 A0σ+					4105	8.1 σ+		A0	501	
4022	8.8 A0σ+		A5	692		4098	8.8 A2κ—			240		4108	7.6 A0σ—		A0	288	
4033	8.9 A0σ—		A2	525		4099	9.9 A0σ—					4110	10.2 A2κ—			457	
4042	10.3 A3κ—			479		4104	9.6 A3κ—			347		4119	8.4 A0μ		A0	302	
4050	9.9 A0μ			603		4107	10.5 A0σ+					4122	8.2 A0σ		A0	380	
4053	10.5 A2κ—			525		4108	10.1 A0σ—					4125	9.9 A0ρ			631	
4055	8.7 B8σ		B9	479		4126	7.9 Bτ				S_1	4129	10.8 A0ρ			955	
4065	8.0 A0σ—		A0	347		4128	9.3 A0σ—			631	S_2	4132	10.1 A2κ—			437	
4066	9.6 A0σ—			724		4130	10.6 A0σ			1148		4134	7.9 A0σ—		A2	331	
4076	7.8 A2ρ		A0	240	S_2	4133	9.3 A0σ			631		4145	7.1 A0σ		A0	229	
						4134	8.6 σ+		A	631		4146	9.4 A0ρ			501	
32°						4142	8.4 A0σ		A0	417		4149	9.5 A2κ—			331	
3730	10.4 A0σ		A0		S_1	4145	9.3 A0τ—			1585		4151	9.8 A0σ+			1096	
3731	8.9 A2κ—		A0	251		4154	7.3 A2κ—		A2	120		4158	9.5 τ—			1738	
3737	9.7 A2κ		A3	288		4155	10.1 A2σ+			1259		4162	9.6 A2κ—			347	
3745	8.4 A2σ		A3	417		4158	7.9 σ+		A0	457		4173	9.7 A2κ—			363	
3748	9.4 Bτ		B3			4159	6.4 A0σ+		A0	229		4174	11.0 A0τ—			3467	
3752	10.2 τ		B			4163	10.8 A0ρ			955		4175	10.3 A0κ—			603	
3753	8.9 A2κ—		A2	251		4165	8.3 A2κ—			191		4177	10.9 A0μ			955	
3764	9.9 A0κ—		A0	501		4171	9.8 A2μ			575		4178	10.4 A0σ—			1047	
3773	7.4 A0σ—		B9	263		4178	9.7 A0σ			759		4179	10.9 A0σ+			1820	
3779	7.8 A0ρ		A0	240		4182	9.7 A2κ—			363		4180	10.4 A0ρ			794	
3788	9.2 A0κ—		A	363		4183	9.6 A2κ—			347		4181	10.4 A2σ+			1445	
3805	10.6 A3κ		A0	398		4185	10.5 A0τ			5754		4182	10.4 A0ρ			794	
3817	9.7 A0σ					4189	10.1 A2κ—			437		4184	8.5 A0σ+		A0	603	
3824	9.9 A0ρ			631	S_1	4195	10.2 A0μ			692	S_2	4197	7.9 A0σ—		A0	331	S_2

B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
30°						29°						28°					
4201	9.0	A0 ρ		417	S_2	4153	11.0	A0 μ		1000	S_2	3830	10.6	A0 τ —		2884	S_2
4202	10.9	τ —		3310		4161	10.4	A2 κ —		501		3837	10.8	A0 σ		1259	
4204	10.0	A0 σ +		1202		4164	8.4	A2 κ —	A2	200		3838	10.7	A0 μ		871	
4218	7.7	B8 τ —	B9	759		4177	10.4	A0 ρ		794		3840	10.5	A2 μ		794	
4225	8.8	A0 σ	A	501		4180	10.3	A0 σ		1000		3845	10.2	A0 σ —		955	
4235	9.5	A0 μ		501		4182	9.5	B8 σ +		955		3852	10.9	A0 σ —		1318	
4240	10.5	A0 σ		1096		4187	10.8	A0 σ +		1738		3868	10.3	A0 σ		1000	
4244	9.5	A0 σ —		692	S_2	4194	10.8	A0 τ —		3162		3869	7.9	A2 κ —	A0	158	
						4197	9.8	A2 κ —		380		3872	10.1	A0 ρ		692	
29°						4202	9.4	A2 κ		251		3875	9.5	A0 σ		692	
4078	9.6	A3 κ —		347	S_2	4208	9.9	A0 σ +		1148		3882	9.8	A2 κ —		380	
4085	7.8	A0 σ +	A0	437		4211	10.1	A3 κ		316		3896	9.5	A0 σ +		955	
4087	10.3	A0 σ		1000		4226	9.5	A3 κ		240		3903	10.2	A0 σ +		1318	
4092	7.4	B τ —	B5	661		4230	10.2	A0 σ +		1318		3905	9.4	A0 σ +		912	
4099	10.6	B τ —		2884		4234	8.6	B8 τ —	A2	1148		3913	10.1	A2 κ —		437	
4101	9.5	B τ —		1738		4240	8.6	A0 σ		457		3915	7.9	B8 σ +	B9	457	
4103	10.1	A0 σ		912		4254	7.9	A0 ρ	A0	251	S_2	3916	7.8	A0 σ	A0	316	
4108	10.6	A0 σ	A0	1148								3920	7.9	B8 σ +	B9	457	
4109	9.2	τ —		1514		28°						3925	9.2	A2 κ —		288	
4112	8.0	A0 σ	A2	347		3798	9.0	A0 σ		550	S_2	3927	10.1	A0 ρ		692	S_2
4115	9.8	A3 κ —		380		3801	10.3	A0 σ +		1380							
4124	8.0	A2 ρ	A0	263		3803	10.4	A0 κ —		631		27°					
4131	6.3	A0 κ —	A0	95		3811	10.3	A0 σ +		1380		3883	10.7	A0 μ		871	S_2
4141	9.9	A0 ρ		631		3817	10.5	A0 μ		794		3885	10.1	A0 σ +		1259	
4145	10.3	A2 μ		724		3826	10.1	A0 μ		661		3909	6.5	B τ	B3	912	S_2
4150	10.3	A0 ρ		759	S_2	3829	9.4	A0 ρ		501	S_2						

C e p h e u s.

61°						61°						60°					
2152	10.5	A0 τ —			Nb	2233	6.3	B τ	B0		Nb	2320	7.0	B τ	B3		Nb
2155	7.5	A2 κ —	A2	132		2237	9.4	A0 σ +				2322	10.4	A0 τ —			
2163	9.5	B τ				2240	9.4	A3 κ —				2324	8.9	A2 κ —	A2	251	
2165	9.8	A3 κ —		380		2241	10.1	A0 σ +				2329	7.7	B8 τ	B8		
2168	10.3	τ —				2242	8.8	A0 σ +				2330	7.8	A0 σ +	A0		
2169	4.8	B τ	B2p		*	2243	8.2	B τ —	A0			2334	7.1	A2 κ —	A2	110	
2178	10.2	A0 τ —				2245	9.0	A0 σ +	A0			2336	10.4	A0 τ —			
2179	10.2	A0 σ —				2246	4.8	B τ	Oe5		*	2338	10.4	A0 τ —			
2180	9.6	A0 τ —				2247	8.3	A0 τ —				2340	9.6	A0 τ —			
2182	9.4	A0 ρ				2260	8.4	B σ —	A0			2341	9.4	A0 σ			
2183	10.1	A0 μ				2261	8.7	A0 σ	A0		Nb	2342	8.8	τ —	B9		
2184	10.1	A0 σ —										2344	9.5	B τ —			
2185	7.9	A2 κ —	A0	158		60°						2345	10.1	B τ —			
2193	5.9	B τ	B2			2264	9.8	A2 κ —		363	Nb	2346	8.1	A2 κ —	A3	174	
2194	7.4	B τ	B2			2266	10.1	B τ				2348	7.1	B τ	B8		
2196	10.1	A0 τ —				2270	10.1	A2 τ —				2349	9.1	B τ —			
2197	9.3	A0 σ —				2271	8.1	A2 κ	A2	138		2350	10.1	A3 κ —			
2199	8.3	A2 κ —	A3	191		2273	9.5	A0 σ —				2351	9.5	B τ —			
2201	9.4	σ +				2276	8.7	B τ —	Oe5			2353	10.2	A2 κ —			
2208	8.0	B τ —	B8			2277	10.1	A0 τ —				2354	9.4	A0 τ —			
2209	7.3	B τ	B3			2282	10.4	A3 κ		363		2356	8.2	B τ	A0		
2211	9.0	B τ —				2283	9.9	A3 κ		288		2358	9.3	A0 κ —		380	
2213	8.9	B τ —				2287	10.3	A0 ρ				2359	9.8	B τ —			
2215	9.8	B τ —				2288	4.8	B τ	A2p		*	2360	10.2	A0 σ +			
2216	7.1	B τ	B3			2301	10.7	A0 σ				2366	10.0	B τ			
2217	7.7	B τ	B8			2303	7.4	A2 κ —	A2	126		2367	9.8	A2 κ		302	
2222	9.6	A0 σ +				2306	9.0	A0 ρ				2368	8.5	A0 ρ	A0	331	
2225	9.6	A0 σ +				2309	10.3	A0 τ —				2369	8.4	B τ			
2230	9.5	A2 κ —		331	Nb	2310	9.6	A0 σ +			Nb	2370	8.6	A3 κ	A2	158	Nb

B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
59°						58°						57°					
2398	9.0	A0 τ —	B		Nb	2350	9.8	A3 κ —	A2	302	Nd	2432	8.9	A0 μ	A0	380	Nd
2408	9.8	B τ	B2		Nd	2358	10.5	A0 τ —				2435	10.6	A0 μ			
2412	9.5	A0 τ	B			2360	10.4	A0 σ +	A			2440	9.9	A0 ρ			Nd
2415	9.0	A0 μ	A2	398	Nd	2365	10.5	A0 σ +				2441	5.4	B τ	B0		Nb
2420	7.5	B τ	B3		Nb	2367	9.8	A3 κ	F0	219		2446	9.8	A2 κ	A5	302	
2423	10.5	τ				2368	9.8	A0 τ	A0			2451	9.5	A0 σ +	A0		
2424	8.2	B τ	B5			2370	10.4	A0 τ —				2452	9.8	A0 σ	A0		
2427	7.6	A0 σ	A0	288		2373	10.2	A0 τ	B			2454	10.6	A0 σ —			
2429	10.7	A0 τ —				2381	7.4	A0 σ	A0	263		2456	10.0	A0 τ —			
2430	8.1	A0 τ	B5			2382	10.8	A0 ρ				2460	10.8	A0 σ			
2431	9.6	A2 κ —	A0	347		2384	9.6	A0 ρ	A2			2463	9.8	A0 σ	B8		
2432	8.1	A0 τ	B9			2388	9.7	A0 ρ				2464	9.8	A0 τ —	B8		
2434	10.4	A0 σ				2391	9.6	A0 σ —	A3			2472	11.0	B τ			
2435	7.5	A0 ρ	A0	209		2395	6.9	A2 ρ	A0	158		2473	10.1	A2 κ —			
2436	6.8	A0 σ —	A0	200			6.6	A0 ρ	A0	138		2484	10.5	A0 μ			
2439	10.3	A0 τ —	B			2398	10.4	A0 μ				2486	10.4	A0 σ —			
2441	10.1	A0 τ —				2401	10.4	A0 σ —				2490	11.0	A0 μ			Nb
2443	7.7	A0 τ	B8			2402	5.3	B τ	Od			2494	9.9	A0 σ +	F0		Nd
2445	8.5	A2 κ —	A0	209		2412	9.8	A2 κ		302		2496	9.0	A2 κ —	A5	263	
2446	9.1	A3 κ —	A5	275		2413	6.9	A0 ρ	A2	158		2504	10.6	B σ +			
2448	9.2	A0 τ —				2416	8.0	A0 σ +	A0			2506	10.7	A0 μ			
2449	10.8	A0 σ				2418	9.8	A0 σ				2511	10.0	A0 σ	A2		
2454	9.8	A0 σ —	B8			2421	9.4	τ	B			2513	10.1	A0 τ			
2456	6.8	A0 τ	B5			2434	9.8	A0 σ	B9			2516	9.9	A2 σ	A3		
2458	10.3	A2 μ				2438	9.4	A0 σ —	A0			2522	10.6	A0 σ			
2459	7.0	A0 σ +	A0	302		2440	8.3	B τ —	B8		Nd	2523	10.4	τ —	B8		
2460	8.2	A3 κ —		182								2524	10.8	A0 τ —	B8		
2461	7.6	A0 σ	A	288*		57°						2525	10.4	A0 τ			
2462	9.8	A2 κ —	A0	380		2348	10.2	A0 μ			Nd	2531	10.3	A0 τ —			
2463	7.8	A0 σ	A0	316		2349	7.9	A2 κ —	A2	158		2535	9.7	A0 τ —	B8		
2464	8.6	A0 ρ	A0	347		2352	10.1	τ —			Nd	2536	10.8	A0 τ			
2466	8.8	A0 σ +	A	*		2354	8.8	B τ	B2		Nb	2538	11.0	A0 σ			
2478	10.2	A2 κ —				2356	9.8	A2 κ —		380		2542	8.2	A0 ρ	A0	288	
2483	9.9	A0 σ +				2358	10.2	A0 σ +				2543	7.9	A2 κ —	A0	158	
2495	9.5	A2 κ	F0	263	Nb	2360	9.8	A0 τ	B5			2551	9.7	A0 τ —			Nd
						2363	9.8	B τ —									
58°						2366	10.2	A0 τ				56°					
2282	8.2	B τ	B8		Nb	2369	9.7	A0 τ —				2605	8.8	B τ	B5		Nb
2283	8.2	A0 σ	A0	380	Nd	2370	10.4	A0 σ				2610	8.6	B τ	A0		
2289	10.1	A0 τ				2372	8.9	B τ	B3			2615	9.8	B τ	B3		
2290	8.0	A0 σ	A0	347		2374	7.0	B τ	B0p		*	2617	5.4	B τ	Oe5		
2294	10.2	A0 τ —				2375	10.0	A0 τ —				2620	7.9	B τ	B3		Nb
2300	7.6	A0 σ	A0	288		2376	9.9	A0 τ				2631	9.4	τ	B3		Nd
2301	9.0	A3 κ —	A0	263		2377	10.3	A0 τ —				2632	9.0	τ	B3		
2302	10.2	A0 τ	B3			2380	10.2	B τ	B2			2641	10.2	A0 σ +			
2306	10.3	A0 μ			Nd	2382	10.8	A0 τ —			Nb	2652	8.5	A0 μ	A0	316	
2315	10.0	B τ			Nb	2383	10.1	A0 σ	A0		Nd	2653	8.5	A0 σ —			
2318	9.4	A3 κ —	A2	316		2386	9.1	A0 σ +	A			2659	10.2	A0 ρ			
2320	9.6	B τ	B0			2389	10.4	A0 μ				2663	10.8	A0 μ			
2324	9.2	A0 μ	A0			2391	9.4	A0 σ	A0			2669	9.3	A3 κ —		302	
2326	10.2	A2 κ —				2400	10.7	A0 σ				2670	6.8	A0 σ	A0	158	
2327	9.8	A0 σ				2401	10.0	A0 σ				2672	9.8	A0 σ	A0		
2328	9.9	A0 τ —	B			2402	8.1	A2 κ —	A2	174		2675	8.7	A0 σ +	A2		
2329	10.5	τ —			Nb	2403	8.1	A2 κ —	A2	174		2676	8.5	B8 τ —	A0		Nd
2335	10.2	A3 κ		331	Nd	2406	10.5	A2 κ —	A			2678	11.0	A0 τ			Nb
2337	10.2	A0 σ —					10.8	A0 σ	A			2679	9.8	A2 κ —		380	
2338	9.6	A3 κ —		347		2411	10.2	A2 κ		363		2680	10.4	A0 σ	A		
2341	10.2	A0 τ —				2413	10.2	A2 κ —				2686	9.7	A2 κ		288	
2342	9.4	A0 μ	A2			2414	8.4	A3 κ —	A2	200		2687	9.4	A0 ρ	A2		
2343	10.0	A0 σ +	B9			2416	9.5	B τ	B2			2693	10.7	A2 κ —			
2344	9.9	A0 τ —	F0		Nd	2422	8.2	A0 ρ	B9	288	Nd	2694	9.4	τ —	B3		Nb

B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
56°						55°						55°					
2695	9.6	A0 κ —	A2		Nb	2654	11.2	A0 μ			Nd	2778	10.4	A0 μ		759	Sd
2699	10.6	A0 σ +				2658	9.2	A2 κ	A2	229		2779	6.2	A0 ρ	A2	115	
2700	10.1	B8 σ +				2662	10.9	A0 σ +				2783	9.4	A0 τ	B	3467	
2705	10.1	A0 τ —				2669	7.4	B τ —	B8			2792	8.7	A0 σ +	A2	661	
2706	8.9	B8 σ +	A0			2671	9.5	A0 μ	A2			2795	9.8	A0 τ —		1995	
2712	9.8	A0 τ —	B3			2675	10.4	A2 σ +				2800	8.5	A0 σ	A3	437	Sd
2713	8.7	A2 κ —	A0			2678	10.0	B8 σ +									
2714	10.8	A0 σ				2679	6.2	B8 σ +	B9	209		54°					
2715	10.5	A0 τ —				2681	10.1	A2 τ —	A			2639	9.6	A3 κ —	A2	347	Nd
2716	10.7	A0 σ				2685	9.5	A0 σ	A0			2640	7.3	B τ —	B8		
2717	9.9	A0 σ				2686	9.3	A0 σ —	B9		Nd	2642	10.2	A0 σ +			
2718	10.2	A2 σ	A			2690	10.5	A0 σ —		1096	Sb	2643	9.7	A2 κ		288	
2719	10.6	A0 ρ	A			2692	8.6	A0 ρ	A0			2644	10.4	A0 σ +			
2720	9.6	A0 τ —	B8			2693	10.7	A0 σ +		1660		2645	10.3	A0 σ			
2722	10.7	A0 σ +				2695	6.8	B8 τ —	B5	501		2648	9.7	B σ +			
2723	10.2	A0 σ +	A2			2696	9.9	A0 τ —		2090		2652	10.5	A0 τ —			
2725	10.3	A0 σ				2698	10.2	A0 κ —		575		2653	10.4	A0 μ			
2733	9.6	A0 τ	B0			2701	9.5	A2 κ —	A	331		2655	10.3	A0 σ +			
2734	9.4	A0 σ	A2			2704	9.3	A0 μ	A	457		2658	10.3	B σ +			
2736	8.2	A0 σ	A2	380		2706	9.2	A2 κ	A2	229		2660	10.9	A0 σ +			
2738	9.0	A0 σ +	B9			2707	9.8	A0 σ		794		2661	8.1	A2 τ —	B5		
2744	9.2	A0 σ —	A0			2708	10.5	A0 μ		794		2662	9.4	B8 τ —			
2745	9.8	A3 κ	A7	275		2709	7.3	B τ —	B9	631		2663	10.4	A0 μ			
2749	9.8	A0 τ —	A5			2710	8.7	A0 σ	A0	479		2665	9.5	A0 σ +	B9		
2752	10.6	A0 τ —				2714	7.0	A0 ρ	A2	166		2666	9.8	A2 κ —		380	
2753	9.7	A2 κ —		363		2715	9.2	A0 κ —	A3	363		2669	10.5	A0 σ +			
2755	6.1	σ +	B8	200		2721	9.3	B τ	Ob	3310		2675	9.5	A3 κ —		331	
2758	10.8	A0 τ —				2722	10.3	A0 τ		5250		2676	10.6	A0 τ			
2759	10.3	A0 σ				2723	8.9	A0 σ +	A	724		2677	6.9	A0 σ	B9	209	Nd
2762	8.6	A2 κ —	A2	219		2725	9.3	A3 κ —		302		2678	9.8	A0 τ —		1995	Sb
2763	10.1	A0 τ —				2726	9.2	A0 σ	A	603		2682	10.4	A2 σ —		1047	
2765	5.9	B8 τ —	B8	331	Nb	2729	7.8	τ —	B9	794		2683	7.8	B τ	B8	1660	
2768	10.5	A0 σ		1096	Sb	2730	10.0	A2 κ —	A2	417		2684	10.2	A0 τ		5012	
2769	10.1	A0 ρ		692		2731	7.9	A0 ρ	A0	251		2689	9.8	A0 μ		575	
2773	10.5	τ —		2754		2734	10.3	A0 σ +		1380		2691	9.8	B8 τ —		1995	
2774	10.1	A0 τ —	B8	2290		2735	9.1	τ —	B8	1445		2695	10.6	A0 σ		1148	
2776	8.3	A0 ρ	A0	302		2736	9.9	A0 τ		4365		2699	10.4	A0 σ —		1047	
2778	9.4	A0 σ +	B5	912		2739	9.8	A0 σ +		1096		2705	9.7	A0 τ —		1905	
2783	10.9	A0 μ		955		2741	10.3	A0 ρ	A	759		2706	9.2	A0 σ		603	
2784	8.3	B σ +	B9	550		2742	10.0	A0 τ —		2188		2708	7.4	B8 σ +	B9	363	
2789	10.1	A0 μ		661		2743	9.2	B8 τ —		1514		2711	10.0	B8 τ —		2188	
2790	8.5	A2 κ —	A0	209		2745	9.9	τ —		2090		2712	9.7	A0 σ		759	
2792	10.1	A0 σ		912		2746	9.2	A2 κ —	A2	288		2716	8.5	A0 μ	A0	316	
2794	7.3	A2 τ	A2p	1318	*	2747	9.3	A2 κ —	A	302		2718	9.9	A0 τ		4365	
2797	9.1	A0 τ —	B9	1445	Sb	2750	6.4	σ +	B8	229	Sb	2719	8.9	A0 ρ	A2	398	
2802	9.6	A0 σ —		724	Sd	2752	10.6	A0 τ —		2884	Sd	2724	9.8	A0 σ +		1096	
2813	8.2	A2 κ —	A3	182		2756	9.5	B τ —	B2	1738	Sb	2726	9.5	B τ		3630	
2818	9.1	B τ	Ob	3020		2757	10.2	A0 τ		5012	Sb	2727	8.8	τ —	B9	1259	
2824	9.4	A2 κ —		316	Sd	2758	10.1	A0 σ		912	Sd	2729	9.8	A0 σ		794	
						2760	10.3	A0 σ +		1380		2730	10.5	A0 σ —		1096	
						2762	10.4	A0 τ		5495		2731	10.6	B τ		6026	
55°						2763	8.8	A0 σ +	A3	692		2732	8.9	A0 σ	A0	525	
2636	10.1	A0 τ			Nd	2764	9.8	A0 μ		575		2735	10.4	τ —		2630	
2637	10.4	A2 κ —				2765	10.1	A0 ρ		692		2737	10.4	A0 τ		5495	
2639	5.5	B τ —	B3	275		2770	9.5	B τ		3630		2739	10.4	A0 μ		759	
2642	10.1	A2 κ —				2771	10.0	B τ		4570		2740	7.9	B8 σ +	B9	457	
2643	9.8	A0 κ —				2772	9.7	A0 μ	A0	550		2743	10.0	A0 σ +		1202	
2644	6.4	B τ	B9p		*	2773	9.9	A0 τ —	B5	2090		2744	10.0	B τ —		2188	
2646	10.1	A2 κ		347		2775	9.8	A0 σ +		1096		2745	9.5	A0 τ	B0	3630	
2648	10.2	A2 κ —				2776	10.2	A0 τ —		2400		2747	9.9	A0 σ		832	
2652	9.1	A2 κ —	A3	275	Nd	2777	10.1	A0 σ		912	Sd	2748	9.0	B8 τ —		1380	Sb

B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B. D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
54°						53°						53°					
2751	8.8	B τ	B2	2630	<i>Sb</i>	2749	8.9	B τ	B2		<i>Nd</i>	2880	10.3	A3 σ		1000	<i>Sb</i>
2755	9.4	A0 σ	A0	661		2752	8.1	A0 σ +	B9			2882	7.7	τ —	A0	759	
2756	7.9	B τ	B2	1738		2753	9.6	A0 σ —				2884	8.4	A0 τ —	A2	1047	
2758	9.3	τ	B2	3310		2758	8.8	A0 σ	A			2885	10.3	A0 τ —		2512	
2759	10.5	A0 τ —		2754		2763	9.7	A0 μ				2886	9.8	A0 σ		794	
2761	10.2	B τ		5012		2766	8.7	A0 σ —	B9			2887	9.1	A0 ρ	A0	437	
2763	9.8	τ —		1995		2767	8.2	A0 σ —	A0	380		2890	10.4	A0 σ +		1445	
2764	9.7	A0 τ		3980		2770	9.6	A0 σ +			<i>Nd</i>	2892	10.5	A3 κ		380	
2765	10.4	τ —	A	2630		2776	9.6	A0 σ +		1000	<i>Sb</i>	2893	10.3	τ —		2512	
2766	10.3	A0 τ		5248		2777	8.5	B8 σ	A0	437		2894	10.2	A0 τ —		2400	
2769	8.2	B8 τ —	B9	955		2781	8.5	A0 σ +	A0	603		2897	6.8	B τ —	B3	501	
2771	8.7	A0 σ +	A0	661		2782	9.2	A0 μ	A0	437		2898	9.1	A0 σ +	B9	794	
2772	9.2	A0 μ	A0	437		2784	10.3	A0 τ		5248		2900	9.3	A0 σ +	B2	871	
2774	10.2	A3 κ		331		2790	10.0	B τ		4570		2902	8.6	A0 σ	A0	457	
2775	9.6	τ		3802		2792	10.4	A0 σ		1047		2908	10.4	A0 σ +		1445	
2780	10.2	A0 σ —		955		2794	9.9	A0 σ		832		2913	10.6	τ —		2884	
2781	10.2	A0 σ +		1318		2797	10.3	A0 σ +		1380		2914	9.0	A0 σ +	A5	759	
2782	9.8	A2 σ		794		2800	7.5	A0 ρ	A0	209		2915	9.2	A2 κ —	A2	288	
2784	10.0	A0 σ +		1202		2803	9.3	A0 σ		794		2918	7.4	A0 μ	A2	191	
2786	11.0	A0 ρ		1047		2806	10.4	A0 σ +		1445		2927	10.5	A0 σ		1096	
2788	9.3	A0 σ	B9	631		2807	10.0	A0 σ —		871		2928	10.1	A2 σ +		1259	
2789	9.9	A0 τ		4365		2808	9.8	A0 σ —		794		2931	8.2	A0 σ —	A0	380	
2790	9.7	B τ		3980		2810	9.0	B τ —	A0	1380		2932	7.2	B8 σ +	B9	331	
2791	9.6	A0 σ +		1000		2812	9.6	A0 σ		724		2933	10.1	B8 σ +	A7	1259	<i>Sb</i>
2795	9.1	A0 σ	A0	575		2813	8.4	A0 σ	A0	417		2937	10.3	A2 κ —		479	<i>Sd</i>
2800	8.8	B8 σ	B9	501		2814	11.0	A0 σ —		1380		2941	10.7	A0 τ —		3020	
2802	10.1	B8 σ	B9	912		2815	8.9	A0 σ	A	525		2944	10.3	A0 σ —	A2	1000	
2803	10.2	A0 σ		955		2818	9.9	A0 σ +		1148		2946	10.1	A0 μ	A7	661	
2804	10.2	A0 σ —		955		2819	9.6	A3 κ —	A0	347		2948	9.9	A0 σ +		1148	
2805	10.6	B τ		6026		2820	9.7	B8 τ		3980		2954	9.7	A3 κ		263	
2806	10.1	A0 σ +		1259		2821	9.1	A0 σ —	A	575		2955	10.0	B τ —		2188	
2807	10.2	A0 σ +		1318		2824	9.0	A0 σ	A0	550		2956	9.6	A0 σ		724	
2809	10.1	B8 τ —		2290		2828	9.4	A2 σ	B9	661		2958	7.7	A0 σ	B9	302	
2810	9.7	B8 τ —		1905		2833	10.0	A0 τ		4570		2959	10.2	A0 σ		955	
2811	10.1	A0 σ +		1259		2835	9.7	A3 κ —		363		2961	7.5	A0 ρ	B9	209	
2814	10.0	A2 τ —	B8	2188		2836	10.1	B τ		4786		2962	10.3	A0 σ +	A5	1380	
2818	9.0	A3 κ	A	191		2838	8.7	B τ	B3	2512		2964	9.1	τ		3020	
2819	10.2	A0 τ —		2400		2839	10.0	A0 ρ		661		2969	9.2	A0 σ +	B9	832	
2820	10.1	A2 σ		912		2841	8.5	A2 σ	A5	437		2976	9.8	A0 σ +		1096	
2821	10.2	A2 τ —		2400		2842	8.8	A0 σ	A2	501		2977	10.7	A0 μ		871	
2825	9.7	A0 ρ	A0	575		2843	9.5	τ		3630		2980	9.3	A0 σ —		631	
2827	8.5	A2 σ —	A0	437		2844	8.3	A3 κ —	A3	191		2983	8.9	A0 σ +	A	724	
2829	10.0	A2 σ +		1202		2845	9.6	A0 μ		525		2989	10.4	A0 σ		1047	
2830	8.4	B8 σ +	A0	575	<i>Sb</i>	2847	10.3	A0 σ +		1380		2990	10.7	B σ +		1660	
2833	9.7	A0 σ —	B9	759	<i>Sd</i>	2848	9.8	A0 σ —		794		2991	9.2	A0 σ +	B8	832	
2834	8.4	A2 κ —	A2	200		2849	8.8	A0 τ —	A3	1259		2994	9.6	A0 τ —		1820	
2835	10.3	B τ —		2512		2850	10.1	A0 τ —		2290		3005	9.7	A0 σ		759	
2836	8.7	A2 κ —	A0	229		2851	8.8	A0 μ	A2	363		3009	8.4	B8 σ +	A0	575	
2837	9.2	A2 κ —	A3	288		2853	9.3	A0 μ		457		3011	8.7	A0 σ +	B8	661	
2839	10.0	A2 σ		871		2854	9.7	A2 κ —		363		3012	9.3	A2 μ		457	
2840	10.3	A0 τ —		2512		2855	9.2	A3 κ	A5	209		3017	10.4	A3 κ	A7	363	
2843	9.2	A0 σ	A	603		2857	9.3	A2 κ —	A2	302		3018	10.6	A0 ρ	A2	871	
2846	8.9	A0 τ —	A0 ρ	1318		2859	10.3	A3 κ		347		3021	10.4	A2 σ		1047	
2849	9.2	A2 κ —	A0	288		2860	10.4	A2 κ —		501		3022	9.6	A0 σ +		1000	
2852	9.0	A0 τ —	B5	1380	<i>Sd</i>	2862	10.1	σ +		1259		3028	10.0	A0 σ		871	
						2864	9.7	A0 ρ		575		3037	9.6	A0 τ —		1820	
						2865	8.6	A3 κ —	A2	219		3038	9.0	A0 σ +	A	759	
53°						2867	9.4	A0 σ		661		3054	10.2	A0 σ +		1318	<i>Sd</i>
2727	7.0	A0 κ —	A2	132	<i>Nd</i>	2868	9.2	A0 σ —	A0	603							
2741	9.3	A0 σ	A2			2870	8.1	A0 τ —	B9	912							
2746	9.7	A0 σ				2877	8.6	A0 τ —	A2	1148	<i>Sb</i>						
2747	10.4	A0 σ															

B.D.	m_{ph}	Sp. U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp.H.	r	Ar.
52°						52°						51°					
3126	8.9	B8μ	A0	380	<i>Sb</i>	3252	9.7	A0σ	A0	759	<i>Sd</i>	3359	8.8	A3κ	A3	174	<i>Sb</i>
3127	9.7	A0μ		550		3254	9.5	A0σ	B9	692		3361	9.0	A0σ	A0	550	
3129	9.8	Bτ		4170		3261	9.2	A0σ+		832		3362	9.3	A0σ+	B8	871	
3134	9.7	A0σ+		1047		3264	10.0	A0σ		871		3368	8.7	A3κ	F0	166	
3135	9.7	A2τ		3980		3267	10.4	A0τ—		2630		3369	8.3	Bτ—	B8	1000	
3141	9.2	Bτ—	B2	1514		3268	10.4	A0ρ		794		3370	10.2	A0μ		692	
3147	10.0	Bτ—		2188		3269	9.0	A0μ	A2	398		3371	8.8	B8σ+	A0	692	
3150	8.4	A0τ—	A0	1047		3270	10.3	A0σ—	B8	1000		3372	7.7	Bτ	B8	1585	
3151	9.6	Bτ		3802		3271	8.0	σ+	B9	479		3373	9.5	A2σ—	B8	692	
3153	8.8	A2τ	B	2630		3279	9.9	A3κ		288		3380	10.2	A0τ—	B5	2400	
3155	8.6	A3κ—	A3	219		3283	9.7	τ—		1905		3382	9.3	A0ρ	B8	479	
3156	9.7	τ		3980		3292	9.0	A0σ—	A0	550		3384	8.7	A0σ—	A0	479	
3158	10.3	A2κ		380		3293	8.1	A0σ—	A0	363		3385	8.8	B8σ+	A0	692	
3159	10.4	A0μ		759		3296	8.9	A0σ+	B8	724		3386	9.8	σ+		1096	
3162	10.4	A0μ		759		3297	9.2	A0σ	A0	603		3388	10.5	A0σ		1096	
3164	9.6	A2σ		724		3301	10.0	A2ρ		661		3390	9.9	τ—	B3	2090	<i>Sb</i>
3165	10.2	A2σ		955		3304	9.8	A0σ		794		3393	9.5	A2σ		692	<i>Sd</i>
3167	8.8	Bτ	B1	2630		3305	10.9	A0μ		955		3397	9.2	A2ρ		457	
3168	8.5	A2μ	A2	316		3309	9.9	τ—		2090		3398	9.8	A0σ—		794	
3171	10.1	A2κ—		437		3311	7.2	A0σ+	A0	331		3400	9.4	A0μ		479	
3173	9.6	A0τ—		1820		3315	8.3	τ	B2	2090		3407	8.8	A0σ	B9	501	
3175	10.2	A2κ—		457		3316	9.6	A0μ		525		3410	9.2	A2μ	A2	437	
3176	9.7	A2κ—		363		3320	10.4	A0σ+		1445		3415	9.0	A0σ+	A0	759	
3177	10.0	A0σ+		1202		3322	9.9	A2κ—		398		3417	10.1	A0ρ		692	
3180	9.9	A0σ		832		3324	10.4	A0σ		1047		3420	8.8	B8σ+	A0	692*	
3182	8.1	A0σ	B9	363		3325	9.8	A0σ+		1096		3421	10.1	A0σ+		1259	
3183	9.6	A0σ+		1000		3333	9.4	A0σ+	A0	912		3430	9.3	A0σ	A0	631	
3185	8.9	A0σ+	A2	724		3335	10.5	A0ρ		832		3433	9.0	B8τ—	A2	1380	
3186	10.3	A0τ—		2512		3336	9.1	A0σ+	B8	794		3436	9.3	A0σ+	B9	871	
3187	9.6	A2κ—		347		3337	10.7	A0σ—		1202		3440	9.8	A2μ	A2	575	
3188	9.5	A0σ—		692		3338	10.1	A0σ+		1259		3445	9.3	A0σ+		871	
3189	9.5	A2κ	A0	263		3340	9.3	A0τ—		1585		3450	10.2	A0τ—		2400	
	10.3	A2μ		724		3344	10.8	A0μ		912		3451	10.4	A0τ—		5495	
3191	10.3	A2κ—		479		3345	9.6	A0σ		724		3452	9.1	A0ρ	A0	437	
3193	10.3	A0σ—		1000		3346	9.1	A0σ—	A	575		3455	9.4	A0ρ		501	
3194	9.8	Bτ—		1995		3355	10.2	A2σ		955	<i>Sd</i>	3462	9.0	A0σ+	B9	759	
3196	9.4	A0σ		661		51°						3465	10.0	A2κ—	A2	417	
3197	9.5	A0σ—		692		3273	9.2	A3κ	A	209	<i>Sb</i>	3466	9.2	A0σ	B9	603	
3198	10.3	Bτ—		2512		3278	10.0	A0σ		871		3471	7.2	A3κ—	A3	115	
3199	8.6	A2ρ	A0	347		3279	10.1	A0σ		912		3473	10.5	A0μ		794	
3200	10.3	A0μ		724		3281	7.3	Bτ	B2	1318		3494	10.5	A2κ—		525	
3203	8.5	B8σ+	A0	603		3286	10.1	A0μ		661		3496	10.2	A0σ—		955	
3205	9.2	Bτ—	A2	1514		3289	10.1	A0τ		4785		3497	8.1	A0σ—	A0	363	
3209	10.3	A0σ+		1380		3293	8.1	A0τ—	B9	912		3498	9.5	Bτ—	B	1738	
3210	10.3	Bτ		5250		3295	7.5	B8σ+	B8	380		3499	8.2	A0τ—	B8	955	
3213	8.5	B8τ—	B9	1096		3300	10.4	A0τ—		2630		3500	10.6	A2κ—		550	<i>Sd</i>
3215	10.4	A2κ—	A	501	<i>Sb</i>	3304	10.4	A0μ		759		3505	10.1	A3κ—		437	<i>S1</i>
3223	10.3	A0κ—		603	<i>Sd</i>	3307	8.3	A0σ+	A0	550		3506	9.0	A0τ—	B9	1380	
3224	10.2	τ—		2400		3315	9.6	A2σ		724		3510	10.4	A0σ		1047	
3225	9.5	A0σ+	B8	955		3319	10.0	τ		4570		3512	9.1	B8τ—	A0	1445	
3226	9.4	A0σ		661		3320	9.0	σ+	B9	759		3513	10.5	A2κ		417	
3228	9.6	A0σ		724		3328	10.3	A2μ		724		3515	6.9	B8τ—	B9	525	
3230	9.6	A0σ+		1000		3330	8.7	Bτ	B2	2512		3517	8.9	A0σ—	A0	525	
3231	9.8	A0σ+	A0	1096		3337	8.9	Bσ+	A	724		3524	9.5	A2κ—		331	
3232	8.6	A0σ	A0	457		3341	6.9	Bτ	B2p	1096		3525	9.8	A0σ	A3	794	
3236	8.1	A0μ	A0	263		3344	9.5	A2κ—		331		3532	10.2	A0σ		955	
3238	9.8	B8τ—		1995		3348	9.7	A0μ		550		3536	9.0	A0σ	A	550	<i>S1</i>
3239	10.1	A3κ		316		3349	9.9	A0σ+		1148							
3241	9.5	A0μ	A0	501		3352	9.4	A0μ	A0	479							
3244	10.2	A0σ		955		3356	9.3	A0σ		631	<i>Sb</i>						
3250	10.4	A0ρ		794	<i>Sd</i>												

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
50°						50°						49°					
3662	10.3	A0ρ		759	<i>Sb</i>	3918	9.9	A0σ		832	<i>S</i> ₁	3993	10.1	A0σ+		1259	<i>S</i> ₁
3722	9.7	A2κ		288	<i>Sb</i>	3919	10.5	A0μ		794		3994	10.2	A0σ+		1318	
3738	9.6	A0σ		724	<i>Sd</i>	3920	10.3	A0σ+		1380		3995	8.9	A2κ—	A3	251	
3739	9.4	A0σ	B8	661		3923	8.7	A0σ	A2	479		3996	10.0	A0σ—		871	
3741	7.7	A0σ—	A2	302		3925	10.6	A0κ—		692		3999	10.4	A2κ—		501	
3743	7.8	A0σ	A0	316		3926	10.2	A0μ		692		4006	9.8	A0μ	A7	575	
3748	9.4	A2τ	B0	3467		3931	9.5	A0ρ	A0	525		4007	10.5	A0κ—		661	
3749	10.1	A0σ+	A	1259		3943	10.1	A0σ+		1259		4015	7.8	A0σ	A3	316	*
3750	10.8	A3κ		437		3946	7.2	Bτ	B5	1259		4016					
3754	9.8	A0σ+		1096		3952	9.7	A0σ—		759		4017	10.1	A0σ+		1259	
3755	8.9	A0σ—	A2	525		3955	8.2	Bτ—	A0	955		4021	10.2	A3κ		331	
3760	10.5	A0σ		1096		3957	9.7	A0ρ		575		4025	10.2	A0σ		955	
3761	9.8	A0ρ		603		3958	9.4	A0μ	A0	479		4027	10.2	A0σ—		955	
3762	10.7	A0μ		871		3963	10.3	A0μ		724		4029	9.5	A0σ+		955	
3767	7.8	A0τ—	A0	794		3967	9.5	A0σ—	B9	692		4039	10.7	τ		6310	
3768	8.0	A0σ+	A0	479		3969	10.1	A0ρ		692		4044	10.8	A2κ—		603	
3769	8.5	A0τ—	A	1096		3979	9.5	A0μ	A0	501		4045	7.6	A0τ	A5p	1514	*
3771	11.0	A0μ		1000		3997	10.0	A0σ	B9	871		4046	9.8	A0τ—		1995	
3773	9.7	A0μ		550		4000	9.4	A0σ+	A2	912	<i>S</i> ₁	4050	10.6	A0σ		1148	
3778	11.0	A0σ		1380								4064	10.8	A0σ		1259	
3786	10.6	A0σ		1148		49°						4071	6.1	A0ρ	A0	110	
3787	9.4	A0μ	A0	479		3874	7.8	A0σ	B9	316	<i>Sd</i>	4073	8.6	A0σ	A0	457	
3789	7.6	A2κ	F0	110		3875	3.7	A2κ—	A0	23		4075	9.1	A0σ+	A0	794	
3792	9.4	A0ρ	A0	501		3876	9.4	A0ρ		501		4076	9.5	A0σ+	A0	955	
3793	10.5	A2τ—		2754		3883	10.2	A2κ—		457		4077	7.9	A0σ—	A0	331	
3795	10.4	A0μ		759		3887	10.5	A2σ+		1514		4092	9.5	B8σ	A0	692	
3797	8.7	A2ρ	A2	363		3894	8.8	A0ρ	A	380		4102	8.7	A0σ+	A0	661	
3799	9.5	A0σ+	A2	955		3895	8.1	A0σ+	A	501	*	4108	8.1	A0σ+	B9	501	
3800	10.4	A3κ		363		3901	10.5	A2κ—		525		4112	10.4	ρ		794	<i>S</i> ₁
3804	10.4	A2κ		398		3902	10.5	A0σ—		1096							
3814	9.5	B8τ—		1738		3903	6.0	Bτ—	B3	347		48°					
3815	10.4	A0τ—		2630		3906	9.9	A2κ—		398		3764	9.2	A0σ+		832	<i>Sd</i>
3816	10.6	A2κ—		550		3908	8.7	A0σ+	A0	661		3772	10.4	A0μ		759	<i>Sd</i>
3817	8.3	A0σ+	B9	550		3913	10.2	A0ρ		724		3778	10.1	A0μ		661	<i>S</i> ₁
3821	10.1	A0τ—		2290	<i>Sd</i>	3914	10.7	A2κ—		575		3781	9.2	A0τ—		1514	
3824	10.1	A0σ+		1259	<i>S</i> ₁	3915	9.4	A0σ	A5	661		3785	10.3	A2σ+		1380	
3826	9.6	A0μ		525		3919	7.6	A0σ	A0	288	<i>Sd</i>	3792	9.6	A0σ—		724	
3832	10.6	A0μ		832		3921	10.6	A2σ+		1585	<i>S</i> ₁	3793	8.8	A2κ—		240	
3842	10.5	A0σ		1096		3922	9.5	A0ρ		525		3795	9.8	A0ρ		603	
3845	9.7	A0σ		759		3925	8.1	A2κ—	A3	174		3799	9.5	A2σ+		955	
3846	8.2	A0ρ	A0	288		3927	10.5	A0σ—		1096		3805	10.2	A0σ+		1318	
3851	9.6	A0σ		724		3932	9.8	A0τ—		1995		3807	9.4	A0σ		661	
3853	9.5	A2κ—		331		3934	9.7	A0ρ		575		3809	7.9	A0σ—	A2	331	
3855	10.3	A0ρ		759		3935	10.6	A0σ+		1585		3819	9.4	A0σ+		912	
3862	10.8	A0σ—		1259		3938	9.5	A0σ		692		3821	9.0	A0σ	A2	550	
3866	10.5	A0ρ		832		3944	9.5	A3κ—		331		3828	8.7	A2μ	A0	347	
3868	8.5	A0σ+	A0	603		3945	11.0	A0μ		1000		3829	9.9	A0σ		832	
3869	11.0	A0σ		1380		3946	10.6	A0μ		832		3831	10.3	A0ρ		759	
3871	8.8	A0ρ	A0	380		3948	9.5	A0σ—		692		3836	10.4	A0μ		759	
3875	8.8	A0μ	A0	363		3949	9.6	A0σ+		1000		3845	10.3	A2σ		1000	
3878	10.2	A0σ—		955		3951	10.0	A2κ—		417		3848	7.8	A0μ	A2	229	
3879	11.0	A0μ		1000		3962	6.2	τ—	B9	380		3850	9.7	A0ρ		575	
3883	9.5	A0τ—	A0	1738		3965	8.2	Bτ—	B5	955	*	3854	10.3	A0σ		1000	
3894	7.7	A0σ+	A0	417		3967	10.1	A2κ—		437		3861	10.6	A0σ+		1585	
3897	8.1	A3κ—	A3	174		3978	10.4	A0μ		759		3863	10.3	A0ρ		759	
3898	9.3	A0σ	A2	631		3980	10.6	A0σ		1148		3867	10.0	A2κ—		417	
3900	7.9	A0τ—	A0	832		3981	9.9	A0σ+		1148		3870	9.7	A0σ—		759	
3902	10.2	A0ρ		724		3983	8.6	A0τ—	A2	1148		3871	10.1	A0σ—		912	
3905	10.3	A0σ+		1380		3985	9.0	Bτ—		1380		3872	9.2	A0μ		437	
3906	10.4	A0σ+		1445		3986	10.1	A0σ		912		3875	9.4	A0σ+		912	
3914	8.9	A0τ—	B9	1318	<i>S</i> ₁	3991	8.0	Bτ—	A0	871	<i>S</i> ₁	3876	10.2	A3κ—		457	<i>S</i> ₁

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
48°						47°						46°					
3890	9.3	A0 ρ		479	S_1	3966	9.6	B σ +		1000	S_1	3932	9.7	A0 σ		759	S_1
3891	9.2	τ —		1514		3972	11.1	A0 σ		1445		3933	7.1	τ	B9	1202	
3895	9.5	A0 ρ		525		3975	10.7	τ —		3020		3936	10.5	A2 κ		417	
3898	10.7	A0 μ		871		3980	9.7	B σ +		1047		3944	10.6	A0 ρ		871	
3899	8.9	σ +		724		3985	4.8	B τ	B3	417		3947	10.1	A0 σ		912	
3900	10.8	A0 μ		912		3988	9.8	A0 μ		575		3949	10.4	A0 μ		759	
3903	9.1	A0 σ	A2	575		3990	8.8	B8 σ +	A2	692		3952	10.4	A2 κ —		501	
3907	10.2	A0 ρ		724		3993	10.0	A0 κ —		525		3962	9.8	A2 κ		302	
3916	9.5	A0 τ —		1738		3994	9.0	A0 σ		550		3965	9.6	A0 σ —		724	
3918	10.3	A0 ρ		759		3997	10.0	A2 κ —		417		3967	10.4	A0 σ —		1047	
3923	10.1	A2 κ —		437		3998	9.3	A2 κ		240		3983	10.6	A2 μ		832	
3924	7.8	A2 κ —	A2	151		4004	10.4	A0 κ —		631		3989	10.4	A0 ρ		794	
3925	10.6	A0 σ		1148		4012	8.9	A0 σ +		724		3992	9.7	A0 σ —		759	
3931	10.6	A0 κ —		692		4015	7.6	A0 σ	A0	288		3993	8.5	B8 τ —	B9	1096	
3932	10.4	A0 σ		1047		4017	7.8	A2 κ —	A0	151		3997	9.7	A2 κ —		363	
3933	9.4	A0 σ +		912		4021	10.3	A2 κ		380		4000	8.9	B8 σ +	B9	724	
3936	10.8	A0 μ		912		4028	9.6	A0 σ		724		4002	9.9	τ		4365	
3938	10.2	B τ —		2400		4032	10.9	A0 σ +		1820		4004	10.6	A0 μ		832	
3941	8.7	B σ +	A2	661		4044	9.3	B τ —		1585		4010	9.4	A0 σ		661	
3945	9.3	A0 τ —		1585		4047	8.5	B τ —	A0	1096		4019	8.6	A0 σ +	B9	631	S_1
3950	6.5	B τ	B3	912		4051	9.6	A0 ρ		550							
3951	10.7	A2 κ —		575		4053	10.2	A0 ρ		724		45°					
3953	10.0	A0 σ —		871		4055	10.8	A0 σ —		1259		4088	8.3	A0 τ —	A0	1000	S_1
3955	10.6	A0 τ —		2884		4060	9.9	A0 σ —		832		4103	10.3	A0 σ		1000	
3956	8.9	B8 τ —		1318		4071	10.5	A0 σ —		1096		4104	8.4	B τ —	A0	1047	
3961	7.4	B τ	A0	1380		4074	10.7	A2 κ —		575		4105	10.4	A0 μ		759	
3968	9.6	A0 σ +		1000		4075	9.6	A0 σ +		1000		4114	9.3	A0 σ +		871	
3969	8.9	A0 ρ	A0	398		4082	10.0	A2 κ —		417		4122	9.3	A3 κ		219	
3972	9.8	A0 σ		794		4083	9.9	A3 κ		288		4126	9.5	A0 τ		3630	
3976	10.6	A0 ρ		871		4103	10.3	A3 κ		347		4129	8.7	A0 τ —	A3	1202	
3982	9.4	A0 ρ	A0	501		4121	10.4	A0 σ —		1047		4133	9.2	B τ		3162	
3983	10.7	A0 ρ		912		4127	10.2	A2 κ —		457	S_1	4134	9.3	A0 ρ	A0	479	
3993	8.7	A0 σ +	A2	661		46°						4138	8.2	A0 σ +	A0	525	
3998	9.9	A0 ρ	A	631		3856	9.1	A0 μ	A0	417	S_1	4144	10.2	A0 μ		692	
4002	10.1	τ		4785		3858	8.1	A0 σ +	A2	501		4147	6.5	B τ	B5	912	
4003	8.9	A0 σ —	A0	525		3859	10.4	A0 σ		1047		4151	10.1	σ +		1445	
4007	9.7	A0 σ —		759		3863	10.0	A0 σ	A0	871		4152	9.7	A2 κ —		363	
4012	10.4	A0 σ +		1445		3871	10.3	A2 κ	A0	380		4154	10.8	A0 μ		912	
4019	9.6	A3 κ	A2	251		3879	10.4	τ		5495		4155	10.5	τ		5754	
4024	9.2	A0 ρ	A0	457	S_1	3887	9.2	A0 σ —		603		4156	9.2	A0 σ		603	
47°						3889	8.5	A0 τ —	A2	1096		4159	10.1	A0 μ		661	
3896	10.4	A0 σ		1047	S_1	3892	10.7	A0 σ +		1660		4161	7.9	B τ —	A0	832	
3926	9.7	A0 σ		759		3895	10.2	A2 κ —		457		4163	9.3	A0 ρ		479	
3930	9.7	A0 μ		550		3896	9.7	A0 σ +		1047		4167	9.1	A0 σ +		794	
3943	8.1	A0 σ +	A0	501		3912	10.8	A0 μ		912		4179	7.0	A0 ρ	A0	166	
3944	7.0	τ —	B9	550		3913	8.4	A0 τ —	A2	1047		4183	9.3	A0 σ +		871	
3950	10.4	A0 σ —		1047		3923	10.3	A0 κ —		603		4189	8.9	B σ +	B9	724	
3962	8.1	A2 κ —	A2	174		3928	9.0	A0 σ +		759		4190	8.6	B τ —	B9	1148	S_1
3964	10.7	A0 ρ		912	S_1	3931	7.9	B τ	B3	1738	S_1						

C a s s i o p e i a.

65°				64°				64°							
205	10.4	A2 κ	398	D	177	10.5	A0 μ	794	D	196	8.8	A2 κ —	A2	240	D
219	10.1	B τ —		D	179	10.2	A0 μ	692		199	10.5	A0 κ —		661	
						185	10.5	A0 ρ	832		201	10.5	A0 ρ		832
64°															
						191	10.1	A0 σ +		205	9.7	A0 μ		550	
172	9.7	A2 κ —	363	D	194	9.6	A0 τ —		D	213	9.7	A0 σ +			D

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
64°						63°						62°					
214	10.2	A2κ—		457	D	260	9.9	A3κ—		398	D	324	10.5	A0σ—			D
217	9.8	A0σ+		871		261	10.0	A0τ				328	9.8	A0σ+			
226	9.7	A3κ		263		262	10.1	A0σ+				332	10.7	A0τ—			
234	10.8	A0σ				265	5.5	A0σ—	A0	110		333	10.0	A2κ—		417	
235	10.7	A0ρ				267	10.8	A0σ—				334	9.1	A2κ—	A0	275	
239	9.8	B8τ—				272	10.6	A0μ		832		338	9.4	A0τ			
244	9.4	A0ρ		501		274	5.9	Bτ	B5p	692*		345	10.7	A0σ+			
250	10.6	A0σ				276	10.8	A0σ				347	10.8	A0σ			
255	10.8	A0μ				278	10.8	A0τ—				349	8.2	A0μ	A0	275	
257	9.9	A0σ		832		279	10.0	A0σ+				351	9.7	A0σ+			
260	9.4	A0σ+				280	9.8	Bτ—				352	10.5	A0ρ		832	
263	9.5	A0σ+				281	7.6	Bτ	B3			353	9.8	A0σ		794	
268	8.0	Bτ—	B3			282	10.1	A0μ		661		357	8.8	A2κ—	A0	191	
272	10.8	A0μ				283	10.8	A0μ				358	9.9	A0σ+			
273	11.0	A0σ				286	10.6	A0σ				364	9.7	A0σ+			
275	10.6	A0σ+				287	8.8	Bτ	B			366	9.7	A0σ		759	D
277	10.5	A0τ—				290	8.2	A0σ	A0	380							
278	8.6	A0σ—	A0	457		292	10.6	A0ρ				61°					
279	9.4	A2κ—		316		295	10.6	A2κ—		550		271	9.8	A0μ		575	D
281	9.4	A0σ—		661		297	9.7	A0σ+				277	9.9	A0τ			
282	6.0	A0ρ	A2	105		298	9.7	A0σ		759		278	9.6	A3κ		251	
285	6.4	A0μ	A0	120		300	10.3	A0τ—				281	8.1	τ	B8		
289	10.4	A0σ				301	8.9	A0σ—	A0			283	10.5	A2κ—		525	
291	9.3	A0τ—	A			303	9.9	A0σ+				285	9.6	τ			
295	7.9	Bτ	B3			304	10.0	A2κ—		417		286	8.8	A0ρ	A0	380	
301	9.9	A0κ—		501		309	10.2	A0σ+				291	7.9	A0σ—	A0	331	
302	9.6	A0τ—				310	8.2	Bτ	B5p			292	10.4	A0σ—			
304	9.8	A0σ—		794		311	9.7	A0ρ		575	D	297	9.9	A0ρ		631	
307	7.4	A2σ	A2	263	D							298	9.9	A2κ—		398	
63°						62°						299	9.9	A3κ—			
191	9.2	A0τ			D	259	8.0	τ	B0p		D	300	10.3	A0τ			
192	9.2	A0ρ		457		262	7.9	A0μ	A0	240		301	9.2	A2κ—	A2	288	
193	8.0	A0ρ	A0	263		263	10.1	A2κ—		437		301	9.3	τ	F8	*	
196	8.9	A2κ—	A0	251		265	10.5	A0τ—				302	10.3	τ—			
197	9.6	A2κ—		347		271	9.3	τ—				304	6.6	A0σ+	B8	251	
200	10.3	A0σ+				275	10.7	τ—				305	10.7	A0τ			
203	9.9	A0τ—				277	7.5	B8σ+	A0	380		307	10.5	A0σ			
209	9.4	A0σ+				278	10.5	A0τ—				308	10.2	A2κ—		457	
213	10.8	A0τ				280	10.4	τ—				310	9.8	A0τ—			
214	9.6	A3κ—	A3	347		283	10.4	A0τ—				312	9.6	τ			
216	9.7	A0κ—		457		285	9.4	A2τ—				313	8.2	A0σ—	A0	380	
217	9.3	A0ρ	A0	479		287	9.4	A0τ—				314	9.4	A0σ+			
218	8.6	Bτ	B			290	10.6	A0ρ				315	10.5	A0τ—			
219	10.6	A2κ—		550		291	10.2	A0σ+				318	10.5	A0σ+			
220	9.7	A2τ—				292	10.8	σ+				319	9.2	A0σ—		603	
222	10.2	A0σ+				294	10.7	A0τ				320	9.5	A0τ—			
225	9.4	τ				296	10.5	A0τ				322	10.7	A0μ			
226	9.6	Bτ				297	9.7	A0τ				327	8.9	A0μ	A0	380	
228	10.8	A0τ				300	10.2	A0τ				329	8.9	A3κ—	A2	251	
230	8.8	A2κ—	A2	240		301	9.1	A0ρ	A2	437		331	10.5	A2κ		417	
231	9.9	A2κ—		398		302	10.2	A0σ—				332	10.1	τ—			
237	11.2	A0μ				303	10.7	A0σ				333	10.0	A2κ—		417	
242	10.5	A0σ—				304	10.6	A0σ+				336	10.7	A0ρ			
243	10.8	A0σ+				306	8.6	A2κ—	A3	219		337	10.8	A0τ—			
246	10.5	A0τ—				309	10.8	A0ρ				338	9.4	A0ρ	A0	501	
247	9.8	A0τ—				310	10.2	A0σ+				339	10.1	A0σ—			
249	9.5	A0σ		692		313	9.9	A0σ+				342	9.9	Bτ			
252	9.9	B8τ—				314	10.0	A0σ+				348	8.8	A0ρ	A0	380	
253	9.7	A0τ				316	10.1	A0τ—				351	9.9	A0κ—		501	
254	10.2	A0τ—			D	320	3.2	A0σ+	B3	52		352	7.6	σ+	A0	398	
						322	8.3	A0σ	A2	398	D	353	10.2	τ—			D

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
58°						57°						57°					
264	9.6	A0ρ	A0	550	D	293	9.8	Bσ+			D	427	9.8	A0ρ	A2	603	B
265	9.0	A0σ	B8	550		294	7.9	A0σ	A0	331		434	9.0	A0σ	A0	550	
269	9.6	τ—	B8			300	10.9	A2σ				435	7.9	A2μ	A2	240	
270	8.0	A3κ—	A2	166		302	9.3	A0σ+	B9			438	10.1	σ+		1260	
271	10.6	τ—				304	9.6	σ+	B8			441	9.8	τ	B2	4170	
273	6.7	A0σ	B9	191		309	9.9	A2κ—	A2	398		444	10.6	A0τ—		2884	
274	9.7	A0τ—	B0			310	10.6	A0κ—	A5	692		445	10.0	Bτ—		2188	
276	10.3	A0σ+				313	10.5	A0σ+				446	9.7	A2κ—	A2	363	
277	10.6	Bτ—				315	8.7	A0σ	A0	479		448	9.6	σ+	A	1000	
278	10.6	Bτ				316	9.3	A3κ	A2	219		449	10.8	A0ρ		955	
279	9.6	σ+	B8			317	9.8	A2κ—	A2	380		451	8.9	Bτ	B8	2754	
281	8.3	τ—	A2			321	10.2	A0σ+				455	9.7	A2κ—	A3	363	
287	10.3	A0ρ		759		322	10.7	A0σ+				459	9.9	τ	B	4365	
290	9.1	A0σ+	A0	794		323	9.8	A0σ+	B8			461	9.0	A2κ—	A2	263	
292	9.6	Bτ				324	8.9	A0σ	B8	525		463	10.4	τ		5495	
293	10.2	A0σ—				328	9.2	A2κ—	B9	288		467	10.1	A0μ		661	
298	10.4	B8τ—				329	11.1	A0μ				469	9.7	Bτ	B2	3980	
299	11.0	A0μ				330	10.7	A0ρ				475	10.0	A0σ—	A0	871	
305	8.5	A0ρ	A0	331		331	9.9	τ	B3			476	9.1	A0σ+	A0	794	
306	9.2	A0σ+	A0	832		332	9.5	A0σ+				477	9.6	A0σ—	A0	724	
307	10.6	A0κ—		692		333	8.6	A0σ+	B9	631		483	10.2	A0τ	B5	5012	
310	10.3	A0τ				334	10.6	A0τ—			D	484	10.4	A0τ—		2630	
311	10.0	A0σ—				335	9.0	A0τ—	B5	1380	B	492	9.5	τ	B3	3630	
313	10.6	A2κ		437		337	9.9	A0τ—		2090		493	10.5	A0σ+		1514	
315	10.1	Bτ			D	339	10.3	τ—		2512		494	6.5	Bτ	A2p	912*	
316	8.8	A0ρ	A2	380	B	340	8.9	τ—	B8	1318		495	9.9	A0σ—	A0	832	
324	9.5	A0σ	B9	692		343	7.2	Bτ—	B8	603		498	9.3	τ	B3	3310	B
326	9.8	A0μ		575		345	9.5	A0ρ	A0	525							
330	8.6	A0ρ	A0	347		346	8.7	B8σ+	B9	661		56°					
331	7.1	Bτ	B3	1202		351	10.3	A0τ—	A5	2512		270	10.9	A0τ			D
332	10.4	A0σ+		1445		352	10.6	τ		6026		272	10.7	A2κ		457	
333	9.3	A0σ		794		354	9.7	A0σ		759		275	9.2	B8σ+	A0	832	
338	9.9	τ—		2090		355	9.6	A0σ+		1000		276	8.1	Bτ	B3		
339	9.6	σ+	A	1000		359	10.1	Bτ		4786		278	9.7	A2κ—	A0	363	
341	6.5	A0ρ	A0	132		362	9.0	B8σ+	B8	759		280	9.2	A3κ—	A2	288	
343	9.8	B8τ		4170		364	10.0	A0σ+		1202		282	10.2	A0μ	A3	692	
344	10.5	A0σ+		1514		368	9.9	A0μ	A0	603		283	10.8	A0σ			
351	10.4	Bτ		5495		370	6.2	Bτ—	B9	380		284	10.6	A0σ			
353	9.8	A3κ		275		372	8.6	A0σ+	A0	631		286	9.9	A0τ—			
354	10.6	A0ρ		871		376	10.7	A0τ—		3020		288	10.2	τ			
356	8.3	τ	B3	2090		377	10.8	A2κ—		603		293	10.7	A0μ			
358	10.5	A2κ—		525		378	9.4	A0τ—	B5	1660		296	10.3	A0σ+			
359	9.0	A2κ	A2	209		379	9.4	A2κ—	A3	316		297	10.7	A2κ—		575	
360	8.9	A0σ—	A0	525		380	10.4	A0σ+		1445		305	10.1	A0μ		661	
361	10.4	A3κ—		501		391	9.4	A0τ—	B3	1660		306	10.7	A0σ			
362	10.0	A0κ—	A0	525		394	9.5	A0σ+		955		307	8.3	A3κ—	A3	191	
364	9.9	A0τ—		2090		395	10.7	A0σ—		1202		308	9.8	A0ρ	A3	603	D
365	10.4	τ		5495		396	9.5	A0ρ		525		314	9.4	A0σ+		912	B
366	9.8	A0σ—	A0	794		399	7.8	Bτ	B0	1660		315	9.5	A0σ+	B9	955	
377	9.8	A0σ—	A0	794		400	9.9	A3κ		288		316	9.9	A0μ		603	
378	9.8	A0σ	A0	794		405	10.8	A0κ—		759		321	8.2	τ—	B9	955	
379	7.9	A0τ—	B8	832		407	9.1	A0ρ	A0	437		325	9.4	Bτ—	B5	1660	
380	10.1	A2κ—	A2	437		408	10.6	A2κ—		550		327	10.2	A0ρ	A0	724	
383	9.1	Bτ	B8	3020		409	9.5	τ	B0	3630		329	10.5	A0ρ	A0	832	
384	9.1	Bτ	B3	3020		412	10.6	A0τ—		2884		330	6.8	A2μ	A2	115	
385	10.0	τ	B5	4570		413	10.5	A0σ+		1514		333	10.3	τ	B	5248	
386	10.4	A2κ	A0	398	B	414	10.6	A0ρ		871		334	6.2	A0σ—	A0	151	
						419	10.3	A0τ—		2512		336	8.4	A2κ	A0	158	
57°						421	11.0	A0σ+		1905		342	8.1	A0μ	A0	263	
285	10.5	A3κ—		525	D	423	9.9	Bτ		4365		343	9.1	A0σ+	B8	794	
288	9.7	A0τ—	B5		D	425	9.4	τ	B	3467	B	344	10.0	A3κ	A0	302	B

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
53°						53°						53°					
388	8.1	B8τ—	A0	912	B	402	10.6	A0τ		6026	B	436	9.7	A0ρ		575	B
389	10.8	A0τ—		3162		405	8.1	A0ρ	A0	275		437	9.6	A0σ	A2	724	
390	10.2	A3κ		331		410	10.5	A0σ		1096		438	9.4	A3κ—	A5	316	
391	9.0	A0σ+	A0	759		423	10.6	A0μ		832		439	5.1	Bτ—	B8	229	B
392	9.9	Bτ	F0	4365 *		425	10.5	A0τ—		2754							
394	8.9	Bτ	B5	2754		427	9.1	A2μ	A0	417		52°					
395	8.7	Bτ	B5	2512		431	10.3	A2κ—		479		396	9.8	A0σ+		1096	B
400	10.5	A0σ	A0	1096		432	9.8	A0ρ		603		433	8.7	Bτ	B0	2512	B
401	8.8	A0τ—	B8	1000	B	435	10.2	A0τ		5012	B						

A u r i g a.

44°						43°						42°					
1141	9.1	A0σ	A2	575	N	1269	10.8	A0μ		912	N	1253	7.5	A0σ—	B9	275	N
1153	9.8	A0ρ		603		1272	6.7	B8σ+	A0	263		1256	10.4	A0σ—		1047	
1161	9.1	A0σ—		575		1273	9.7	A0σ		759		1257	10.4	A0σ		1047	
1162	9.2	A0σ		603		1282	9.7	A0μ	A	550		1259	9.0	A0σ	A0	550	
1167	8.8	A0ρ	A0	302		1284	9.7	A0ρ		575		1264	8.7	A0σ	A0	479	
1171	8.9	B8τ—	B9	1318		1286	11.0	A0κ—		832		1267	9.9	A0μ		603	
1179	10.5	A0κ—		661		1289	9.8	A2κ—		380		1270	10.5	A2κ—		525	
1180	9.6	A0σ		724		1290	9.1	A0σ+	B9	794		1275	10.5	A0μ		794	
1188	9.6	A0σ		724		1293	8.9	A0σ+	A0	724		1277	10.6	A2σ		1148	
1195	8.7	A2κ—	A2	229		1294	9.1	A0σ—	A2	575		1280	9.5	Bτ—		1738	
1199	10.1	A0μ		661		1296	10.4	A0μ		759		1286	10.1	Bτ		4786	
1205	9.5	A3κ—		331		1298	9.6	A0μ		525		1288	9.7	A0τ		3980	
1219	10.0	A0μ		631		1301	6.9	A0μ	B9	151		1289	10.7	A0σ+		1660	
1223	9.2	A0τ—	B8	1514		1302	9.9	A2τ—		2090		1291	8.6	A2ρ	A2	347	
1227	7.8	B8σ+	B8	437		1307	10.2	A0ρ		724		1294	9.9	A0μ		603	
1231	10.1	A2κ		347		1308	10.3	A0σ+		1380		1297	9.9	A0σ—		832	
1233	9.0	A0μ	A0	398		1311	8.7	A0σ—	A2	479		1299	10.6	A0σ		1148	
1234	9.8	A0ρ		603		1323	10.1	A3κ		316	N	1304	9.5	A2κ—		331	
1243	10.0	A0τ—		2188	N							1305	8.8	A0σ—	A0	501	
						42°						1306	11.1	A0σ		1445	
						1182	9.0	A0τ—	B9	1380	N	1307	9.6	A0ρ		550	
43°						1185	9.8	A0τ—		1995		1312	7.9	A0σ—	B9	331	
1201	10.6	A0σ		1148	N	1189	9.6	A2κ		275		1318	9.7	A0μ		550	
1203	8.7	A0σ—	B9	479		1191	10.8	A0μ		912		1321	10.4	A0μ		759	
1205	10.2	A0κ—		575		1192	9.2	A3κ		209		1322	10.8	A0μ		912	
1208	10.3	A0κ—		603		1193	8.0	A0σ+	B9	479		1323	8.4	A0σ+	B9	575	
1212	9.8	A0κ—		479		1194	10.4	A0σ+		1445		1326	10.6	A0μ		832	
1213	10.2	A0μ		692		1195	9.8	A0σ		794		1327	9.8	A0σ		794	
1215	8.6	A0σ—	B9	457		1197	7.9	Bτ—	B8	832		1328	11.1	A0μ		1047	
1216	10.3	A0κ—		603		1199	9.9	A0τ—		2090		1329	10.5	A2κ—		525	
1221	8.2	B8τ—	A3	955		1200	10.3	A0μ		724		1330	9.8	A0κ—		479	
1222	9.2	A0σ—	A2	603		1203	10.0	A0κ—		525		1331	9.5	A0ρ		525	
1224	9.6	A0μ		525		1205	9.7	A0μ		550		1332	10.4	A2κ		398	
1227	10.4	A2κ—		501		1206	9.8	A0ρ		603		1333	9.0	A0μ	A0	398	
1229	10.3	A0σ—		1000		1207	10.3	A0σ+		1380		1335	10.6	A0μ		832	
1230	10.2	A2κ—		457		1209	10.3	τ—		2512		1339	9.7	A3κ		263	
1239	10.2	A3κ		331		1213	9.8	A0σ		794		1340	9.3	A0σ—		631	
1241	10.5	A0σ		1096		1217	10.5	A0σ—		1096		1346	10.5	A0μ		794	
1246	10.9	A0σ+		1820		1225	9.7	A0μ		550		1361	9.3	A0ρ		479	N
1247	10.5	A0μ		794		1227	7.8	A0ρ	A0	240							
1249	10.2	A0τ—		2400		1229	10.2	A3κ		331		41°					
1250	8.0	B8τ—	B9	871		1235	10.4	A0μ		759		1020	9.1	A0σ+	A	794	N
1253	9.8	A0σ		794		1236	9.5	A0σ		692		1022	8.7	B8τ—	B9	1202	
1259	9.1	A2κ—		275		1244	10.7	A3κ—		575		1024	9.5	A0σ+		955	
1264	8.9	A0σ—	A0	525		1249	9.4	A0ρ		501		1025	9.7	A0σ+		1047	
1267	10.6	A0μ		832	N	1250	9.1	A0σ		575	N	1028	10.3	A2τ		5248	N

B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.	B.D.	m_{ph}	Sp.U.	Sp.H.	r	Ar.
41°						41°						40°					
1031	9.0	A0τ—		1380	<i>B</i>	1179	10.1	A0σ		912	<i>N</i>	1167	9.8	B8τ—		1995	<i>B</i>
1034	10.0	A0σ+		1202		1181	7.5	B8σ+	<i>B5</i>	380		1168	9.9	A0μ		603	
1038	9.2	A0σ+		832		1187	9.7	A0ρ		575		1172	9.9	Bτ—		2090	
1044	6.2	A0σ+	<i>A0</i>	209		1188						1173	9.1	A0σ+		794	
1045	10.3	A0σ		1000		1190	9.9	A0κ—		501		1181	9.9	A0τ		4365	
1046	8.7	B8τ—	<i>B9</i>	1202		1191	9.4	A0σ		661		1185	10.0	Bσ+		1202	
1048	9.7	A0σ		759		1192	9.7	A0μ		550		1186	10.4	A0σ+		1445	
1050	7.2	A2κ—	<i>A2</i>	115		1194	10.6	A0σ+		1585		1187	9.8	A0σ—		794	
1051	8.6	A0τ—	<i>A0</i>	1148		1195	10.1	A0σ		912		1188	10.8	A0μ		912	
1052	10.2	A0σ+		1318		1196	10.0	A0ρ		661		1189	8.8	Bτ—		1259	
1054	9.7	A0σ		759		1198	11.0	A0ρ		1047		1190	10.4	A0μ		759	
1056	9.8	A0σ+		1096		1203	9.0	A0ρ		417		1191	9.5	A0σ+		955	
1057	9.3	A0τ—		1585		1204	10.1	A2κ—		437		1196	8.0	A0τ—	<i>B3</i>	871	
1058	3.0	Bτ—	<i>B3</i>	87		1205	7.8	A0σ+	<i>A0</i>	437		1200	10.3	A0σ		1000	
1060	10.2	A0τ—		2400		1207	10.0	A0σ		871		1202	9.6	A0σ—		724	
1069	9.8	A0σ—		794		1208	9.8	A0ρ		603		1204	10.6	A0ρ		871	
1075	8.7	B8τ	<i>B9</i>	2512		1209	10.4	A0κ—		631		1207	9.8	A0σ+		1096	
1077	8.7	A0ρ	<i>A0</i>	363		1211	9.8	A0ρ		603		1209	10.3	A3κ		347	
1082	8.7	A0σ—	<i>A2</i>	479		1214	9.4	A0μ		479		1210	10.8	A0σ—		1259	
1084	10.6	A0μ		832		1215	9.9	A0σ—		832		1213	7.5	Bτ	<i>B3</i>	1445	
1085	10.4	A0τ—		2630		1218	6.3	A0σ+	<i>B8</i>	219		1216	9.3	τ—		1585	
1086	10.1	A3κ—		437		1219	9.7	A0μ		550		1219	10.2	A0σ+		1318	
1087	9.5	A0σ		692		1221	9.1	A0σ—		575		1221	11.2	A0τ—		3802	
1088	8.5	A3κ—	<i>F0</i>	209		1223	10.0	A0μ		631		1225	9.0	A0σ		550	
1094	9.1	A0τ—		1445		1224	9.7	A0μ		550		1227	10.6	A0σ+		1585	
1097	9.6	A2ρ		550		1225	9.2	A0σ		603		1229	9.8	A0τ—		1995	
1098	10.5	A0ρ		832		1226	8.6	A0σ	<i>A0</i>	457		1231	8.9	A0ρ	<i>A2</i>	398	
1100	9.6	A0σ+		1000		1227	8.3	A0σ	<i>A0</i>	398		1232	9.8	A0σ+		1096	
1101	8.1	Bτ	<i>A3</i>	1905*		1230	8.5	A0ρ	<i>A0</i>	331		1233	10.4	A2κ—		501	
1102	7.9	A2μ	<i>A0</i>	240		1233	8.9	A0μ	<i>A0</i>	380		1237	9.7	τ		3980	<i>B</i>
1103	9.1	A0σ—		575		1234	10.4	A0μ		759		1242	10.4	A3κ		363	<i>N</i>
1105	8.3	A0τ—	<i>B8</i>	1000		1236	10.3	A0μ		724	<i>N</i>	1244	8.8	A2σ+	<i>A2</i>	692	
1106	7.9	Bτ	<i>B3</i>	1738								1246	9.8	A0τ—		1995	
1111	8.8	A0ρ	<i>A0</i>	380		40°						1247	8.2	A0σ+	<i>A0</i>	525	
1117	8.3	A2κ—	<i>A2</i>	191		1079	9.7	A0τ—		1905	<i>N</i>	1248	9.2	A2κ—		288	
1119	10.6	A0σ		1148	<i>B</i>	1091	9.7	A0ρ		575		1249	9.6	A0σ		724	
1126	9.5	Bτ—		1738	<i>N</i>	1092	9.7	B8τ—		1905		1252	10.3	A0ρ		759	
1127	8.3	A2κ—	<i>A2</i>	191		1094	10.2	A0τ—		2400		1253	5.6	A2κ—	<i>A3</i>	55	
1129	9.2	A2ρ		457		1095	10.3	A0μ		724		1254	9.6	A0ρ		550	
1130	9.3	A0σ		631		1097	10.2	A2κ		363		1255	7.1	A0σ—	<i>B9</i>	229	
1131	9.7	A0σ+		1047		1104	10.9	A0μ		955		1258	9.8	A0σ—		794	
1135	9.3	A0σ		631		1106	9.8	A3κ		275		1261	10.6	A0μ		832	
1137	8.8	A2κ—	<i>A2</i>	240		1108	10.2	A0τ—		2400		1264	9.3	A0ρ		479	
1138	8.4	A2κ—	<i>F0</i>	200		1109	10.4	A0σ+		1445		1265	9.8	A3κ		275	
1139	9.4	A0τ—		1660		1110	11.0	A0μ		1000		1267	8.2	Bτ—		955	
1141	10.6	A0ρ		871		1112	10.6	A2κ		437		1268	5.6	A2μ	<i>A3</i>	83	
1142	10.6	A2κ—		550		1114	9.0	τ—	<i>A</i>	1380		1270	11.0	A0ρ		1047	
1144	10.4	A0τ—		832		1117	8.7	B8τ—	<i>B9</i>	1202		1273	9.0	A0σ	<i>B9</i>	550	
1148	10.3	A2κ		2630		1118	10.1	A0σ		912		1276	10.0	A0σ+		1202	
1152	8.1	A3κ—	<i>A2</i>	174		1119	10.3	A0κ—		603		1278	10.8	A0σ		955	
1162	5.1	B8σ+	<i>B3</i>	126		1120	9.2	A2σ+		832		1288	10.4	A2κ—		501	
1163	9.0	B8τ—		1380		1121	9.3	A0τ—		1585	<i>N</i>	1289	11.0	A0σ—		1380	
1166	9.1	A0ρ		437		1134	10.2	A3κ—		457	<i>B</i>	1290	9.3	A0σ		631	
1169	9.9	A0ρ		631		1136	10.6	A0μ		832		1291	8.0	A0σ—	<i>A0</i>	347	
1171	9.5	A3κ—		331		1140	9.8	A2τ—		1995		1295	10.3	A0ρ		759	
1172	9.9	A0σ—		832		1141	8.9	A0σ—	<i>A0</i>	525		1296	9.3	A0σ	<i>A</i>	631	
1174	9.8	A0σ—		794		1148	10.4	A0σ		1047		1298	9.4	A0σ—		661	
1175	8.6	A0μ	<i>A0</i>	331		1151	9.8	A0σ—		794		1301	10.7	A0μ		871	
1177	9.7	A3κ		263		1154	7.9	σ+	<i>B8</i>	457		1306	10.1	A3κ		316	
1178	9.9	A0σ		832	<i>N</i>	1155	10.5	A0μ		794		1311	9.5	A0σ+		955	
						1156	9.9	A2σ		832	<i>B</i>	1312	10.4	A0κ—		631	<i>N</i>

B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.	B.D.	m_{ph}	Sp. U.	Sp. H.	r	Ar.
37°						37°						36°					
963	9.9	A0 ρ			S	1111	9.7	A0 ρ	A0	575	B	1020	11.1	A3 κ —		692	B
964	9.7	A2 σ +				1112	9.7	A0 τ —		1905		1021	8.2	B τ	B2	1995	
993	10.4	A0 σ +				1116	10.4	A0 μ		759		1025	8.7	A0 τ —	B9	1202	
994	10.5	A0 μ				1117	9.0	A0 σ +	A0	759		1026	8.8	A0 σ +	B9	692	
997	10.8	A0 σ				1122	9.4	A0 τ —		1660		1028	9.7	A0 τ —		1905	
998	10.6	A0 μ				1125	9.7	A0 ρ		575		1029	10.4	A0 μ		759	
1004	10.6	A2 κ			S	1127	7.9	A0 σ +	B8	457		1030	10.2	A0 τ —		2400	
1005	5.0	A0 μ	A0	63	N	1128	10.5	A0 μ		794		1031	10.6	A0 τ —		2884	
1011	9.7	A2 κ —	A0	363		1130	9.3	A0 τ —		1585		1037	9.8	A0 σ		794	
1014	8.1	A0 σ —	A0	363		1131	9.8	A0 σ —		794		1039	10.5	A0 σ —		1096	
1017	10.1	A3 κ		316		1133	10.6	A0 ρ		871		1042	9.7	A2 κ —		363	
1019	9.8	A0 ρ	A0	479		1134	9.2	A0 σ —	A0	603		1047	6.7	A0 ρ	A0	145	
1020	9.7	A0 μ	A0	550		1135	9.6	A0 τ —		1820		1048	10.4	A0 σ		1047	
1022	10.4	A0 ρ		794		1137	10.6	A0 σ		1148		1049	7.4	A0 τ —	B8	661	
1024	10.9	A2 σ		1318		1139	9.2	A2 κ —	A0	288		1060	9.0	σ +	B9	759	
1026	9.4	A0 μ	A0	479		1140	9.7	τ —		1905		1062	9.3	A0 σ	A0	631	
1031	7.4	A0 τ —	B8	661		1141	8.6	B8 τ —	B5	1148		1066	9.2	A0 σ	A0	603	
1046	8.7	A2 κ —	A2	229		1142	10.3	A0 ρ		759		1067	8.7	A0 μ	A0	347	
1048	10.4	A0 τ —		2630		1146	6.7	B τ	Oe5	1000		1072	9.2	A0 ρ		457	
1050	10.6	τ		6026	N	1148	10.2	A0 σ		955		1073	7.9	B τ —	B5	832	
1051	9.1	A3 κ —	A5	275	B	1150	8.9	A2 κ —	A0	251		1074	10.3	A0 σ —		1000	
1052	10.3	A0 τ —		2512		1152	10.2	A0 σ +		1318		1077	10.4	A0 σ		1047	B
1057	11.2	A0 σ		1514		1154	10.2	A0 σ		955	B	35°					
1058	10.5	A0 σ —		1096		36°						885	9.0	A3 κ —	F0		S
1059	10.6	A0 σ		1148		913	9.6	A0 τ			S	893	8.0	B8 σ	A0		
1061	9.5	τ —		1738		915	10.3	A0 σ —				897	9.0	A0 σ —			
1065	9.8	A0 σ +	B9	871		921	10.5	A3 κ				898	11.0	A3 κ			
1067	6.9	B τ	B2	1096		926	8.0	B τ —	B9			907	9.7	A0 ρ			
1068	9.7	A0 τ		3980		940	10.3	A2 κ —				916	8.9	A3 κ —	A2		
1070	9.7	A2 τ —		1905		944	9.8	A0 σ				917	8.0	A0 σ +	A0		
1072	8.8	B τ		2630		954	9.8	A0 ρ	A0	*		925	9.4	A0 ρ	A0		
1073	9.8	A0 ρ		603		959	9.9	A0 ρ				927	10.5	A0 τ			
1074	10.4	A0 σ	B8	1047		960	10.5	A0 μ				930	6.2	B τ	B2		
1075	10.8	A0 σ —		1259		961	9.7	A2 κ —				932	9.9	B τ			S
1078	10.2	A0 σ +		1318		966	10.3	A3 κ			S	34°					
1086	10.4	A0 σ —		1047		975	7.4	A0 σ	A0	263	N	903	10.4	A0 σ			S
1089	10.9	A0 σ —		1318		983	9.6	τ —		1820		909	9.7	A0 μ			
1090	9.9	A0 σ +		1148		992	9.7	A0 ρ		575		928	9.8	A0 σ			
1093	9.4	B τ —		1660		997	11.3	A0 σ		1585		930	8.8	A0 σ —	A2		S
1095	10.8	A2 κ		479		998	11.1	A0 σ		1445		33°					
1098	10.5	A0 σ —		1096		999	10.7	A0 τ —		3020		891	9.0	A0 σ +	A0		S
1101	10.4	A0 ρ		794		1000	8.9	A0 μ	A2	380		906	10.4	A0 σ			
1102	10.2	A0 σ +		1318		1004	9.1	A2 κ —	A3	275		907	8.8	A3 κ	A3		
1103	9.6	A0 σ +		1000		1008	10.0	A0 τ —		2190		910	10.3	A0 τ —			
1104	10.5	A0 μ		794		1009	10.3	A0 τ —		2512		930	10.5	A2 κ —			S
1105	10.3	A0 τ		5248		1012	9.7	B τ —		1905	N	935	10.7	A2 κ —			
1106	10.9	A0 μ		955		1016	9.8	A3 κ		275	B	32°					
1107	10.4	B τ —		2630		1017	10.5	A0 σ +		1514		31°					
1108	10.3	A0 σ		1000		1018	10.6	A0 σ		1148	B	30°					
1109	9.5	A0 σ	A0	692		29°						28°					
1110	9.9	B τ —		2090	B	27°						26°					

PART II.

C y g n u s.

No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.	No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.
1	19 ^h 24 ^m .8	41° 3'	10.7	A0 ρ		912	N_2	53	20 ^h 4 ^m .7	35° 47'	10.4	A0 τ —	B2	2630	N_1
2	26.1	40 25	10.6	A0 ρ		871		54	4.8	35 11	10.4	τ —	B3		S_1
3	30.9	42 56	10.5	A0 μ		794		55	5.9	35 46	10.3	A0 κ —	A0	603	N_1
4	36.2	39 35	10.6	B τ —		2884		56	6.1	35 8	10.4	τ —	B3		S_1
5	39.6	38 2	10.2	A0 σ +	A0	1318		57	6.9	36 16	10.5	A0 μ	A0	794	N_1
6	44.9	39 34	10.2	A0 ρ	A0	724*		58	6.9	35 22	10.5	A0 τ —	B9	2754	N_1
7	45.1	42 5	10.4	A2 κ		398		59	7.8	36 21	10.5	A0 τ —		2754	N_1
8	45.5	38 54	10.4	A0 μ	A0	759		60	8.0	33 14	10.1	A3 κ	F0	316	
9	46.3	41 13	10.4	A0 σ	A2	1047		61	8.3	36 18	10.5	A0 ρ	A0	832	N_1
10	46.5	38 40	10.5	A0 σ —	A2	1096		62	8.5	37 27	10.7	A0 ρ	A2	912	
11	46.6	38 22	10.4	A0 σ	B5	1047		63	8.6	35 46	10.5	A2 μ	A0	794	
12	47.9	37 45	10.1	A2 κ —	A0	437		64	8.8	35 35	10.4	τ —	B3	2630	
13	48.6	41 25	10.3	A0 σ +	A2	1380		65	9.2	35 31	10.5	A0 μ	A2	794	
14	48.9	37 8	10.4	A0 ρ		794		66	9.2	35 27	10.7	A2 κ —	A	575	
15	51.0	39 8	10.6	A0 μ	A2	832		67	9.5	36 16	10.5	τ —	B9	2754*	
16	51.2	39 9	10.7	A0 μ	A0	871		68	9.9	35 26	10.4	A2 κ —	A2	501	N_1
17	51.4	40 53	10.4	A0 μ	A0	759	N_2	69	10.6	35 38	8.9	A0 σ	A	525*	S_1
18	51.5	37 23	10.5	A2 ρ	A3	832	N_1	70	11.0	35 56	10.3	A0 μ	A0	724	
19	51.8	40 58	10.4	A3 κ —	A5	501	N_2	71	11.4	34 17	10.6	τ —	A0		S_1
20	52.0	37 18	10.5	A0 μ	A2	794	N_1	72	11.5	39 20	10.5	A0 σ —	A0	1096	N_1
21	52.4	37 55	10.3	A0 ρ	A2	759		73	11.8	33 42	10.6	A0 μ	A0		S_1
22	53.1	37 12	10.5	A0 μ	A	794		74	12.1	33 30	10.6	A0 σ +	A2		S_1
23	53.2	37 53	10.6	A0 ρ	A2	871		75	12.8	39 48	10.6	A0 σ	A0	1148	N_1
24	53.8	38 14	10.2	A0 σ	A2	955		76	12.8	37 33	10.6	A0 τ		6026	
25	53.9	37 57	10.4	A0 κ —	A0	631		77	12.9	37 22	9.9	τ	B	4365	
26	53.9	37 4	10.5	A0 τ —	B8	2754		78	14.1	37 29	10.6	τ		6026	
27	54.4	37 16	10.3	A0 τ —	B5	2512		79	15.7	37 51	10.2	A2 κ —	A0	457	N_1
28	54.9	38 17	10.2	A0 σ +	A0	1318		80	15.8	33 16	10.6	A0 μ	A3		S_1
29	55.4	35 30	10.3	A0 μ		724		81	15.9	37 8	10.6	A0 μ	A2		
30	56.0	38 39	10.6	A0 σ —	B3	1148		82	16.1	36 16	10.7	A0 μ	A0		
31	56.5	40 30	10.7	A0 σ —	B8	1202		83	16.7	34 56	10.2	A0 ρ	A	724	
32	58.3	38 55	10.5	A2 ρ	A0	832	N_1	84	16.7	34 55	9.8	A0 σ	A		
33	58.4	41 8	10.8	A0 μ	A0	912	N_2	85	16.8	34 32	10.4	A0 τ —	B9		
34	58.6	39 29	10.3	A0 κ —	A2	603	N_1	86	17.2	37 45	10.8	A0 σ +	A		
35	58.7	41 31	10.7	A2 κ —		575	N_2	87	17.4	34 49	10.4	A0 μ	A0	759	
36	58.9	41 0	10.7	A0 μ		871	N_1	88	17.5	34 29	10.5	A0 μ	A0	794	
37	59.0	38 41	10.1	A0 κ —	A2	550		89	17.7	37 27	10.4	A0 μ	A0	759	
38	59.6	39 41	10.5	A3 κ —	A3	525		90	18.7	37 37	10.6	A0 σ	A0		
39	59.7	39 35	10.5	A0 σ —	A5	1096		91	19.5	36 15	10.6	A0 μ	A0		
40	19 59.7	37 59	10.1	A2 κ —	A3	437		92	19.9	35 2	10.6	A2 μ			
41	20 0.2	35 35	10.4	A0 τ		5495		93	20.8	38 11	10.5	τ	B9		
42	1.3	37 54	10.6	A0 μ	A0	832		94	21.0	37 40	10.7	A2 τ —	B9		
43	1.3	37 25	10.3	A2 κ —	B9	479		95	21.3	34 45	10.1	A3 κ —		437	
44	1.6	38 33	10.4	A0 μ	A	759		96	24.5	32 36	10.4	A0 σ —			S_1
45	2.2	35 40	10.4	A0 τ —		2630		97	24.6	30 52	10.4	A0 σ +		1445	S_2
46	2.3	34 56	10.3	A2 σ	B8	1000		98	27.7	32 26	10.5	A0 μ			S_1
47	2.4	34 36	10.3	A2 κ —	A2	479		99	27.9	36 5	10.6	A0 μ			
48	2.5	35 58	10.4	A0 ρ	B9	794		100	28.4	33 21	10.6	A2 κ —		550	
49	2.6	35 26	10.5	τ	A	5755		101	29.4	33 45	10.5	A0 σ +			
50	3.1	35 37	10.5	A0 ρ	A0	832		102	29.6	37 37	10.6	τ —			
51	3.4	40 23	10.2	A2 κ —	A3	457		103	29.9	37 35	10.7	A0 μ			S_1
52	20 ^h 4 ^m .0	35° 28'	10.5	A0 μ		794*	N_1	104	20 ^h 30 ^m .1	31° 52'	10.7	A0 μ		871	S_2

No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.	No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.
105	20 ^h 30 ^m .5	31°41'	10.2	A0 ρ		724	S_2	118	20 ^h 37 ^m .9	28°48'	10.6	A0 ρ		871	S_2
106	31.3	37 17	10.6	A0 μ			S_1	119	38.1	33 25	10.6	A2 κ —		550	
107	31.5	30 44	9.9	A0 σ +		1148	S_2	120	39.0	33 38	10.6	τ —		2884	S_2
108	31.6	37 27	10.2	A0 τ —			S_1	121	39.7	35 38	10.3	A0 ρ		759	S_1
109	31.7	35 34	10.4	A2 κ —		501	S_1	122	39.8	33 45	10.3	A2 μ		724	S_2
110	34.9	31 3	10.4	A0 τ —		2630	S_2	123	40.0	32 58	10.4	A3 κ		363	
111	35.1	28 40	10.1	A2 ρ		692		124	40.8	34 52	10.5	A2 κ		417	
112	35.9	32 35	10.5	A2 κ —		525	S_2	125	41.9	32 58	10.6	A2 κ —		550	
113	36.0	35 29	10.5	A0 ρ			S_1	126	43.1	32 33	10.3	A0 μ		724	
114	36.3	35 19	10.5	A0 ρ			S_2	127	46.7	33 26	10.5	A0 μ		794	
115	36.3	28 42	10.7	A0 μ		871		128	47.0	33 4	10.1	A0 σ +		1259	
116	36.5	33 52	10.7	A0 μ		871	S_2	129	48.5	31 30	10.6	A0 σ +		1585	
117	20 ^h 36 ^m .7	33°29'	10.3	A0 σ			S_1	130	20 ^h 49 ^m .4	31°48'	10.5	A0 σ +		1514	S_2

C e p h e u s.

131	21 ^h 31 ^m .6	58°11'	10.1	τ			Nd	175	22 ^h 2 ^m .7	54°49'	10.1	A0 τ —		2290	Sb
132	33.5	57 34	10.3	A0 σ —			Nb	176	3.6	58 8	10.7	A0 σ			Nb
133	36.2	57 2	8.2	τ				177	4.0	55 0	10.6	A0 σ —		1148	Sb
134	36.3	61 52	10.3	A0 σ +				178	4.1	60 9	10.4	A0 τ —			Nb
135	36.8	57 9	9.5	B τ —				179	4.6	56 2	10.3	A2 σ		1000	Sb
136	37.1	57 3	10.2	A0 τ				180	4.6	55 39	10.5	A0 τ —			Nd
137	38.2	57 17	10.3	A0 σ +				181	5.4	58 37	10.3	τ —			Nd
138	39.5	58 30	10.4	τ —				182	5.4	54 9	10.5	B8 τ —		2754	Sb
139	39.6	61 59	10.1	A0 σ +				183	5.5	54 49	10.5	A0 τ —		2754	Sb
140	41.2	58 28	10.3	A0 σ				184	6.1	58 35	10.2	A0 κ —			Nd
141	41.9	58 51	10.5	A0 τ				185	6.4	57 57	10.5	A0 μ			Nb
142	47.7	59 26	10.6	A0 σ +			Nb	186	6.5	54 13	10.4	A0 τ —		2630	Sb
143	48.1	58 53	10.4	A0 τ			Nd	187	7.1	53 51	10.4	A0 τ —		2630	
144	50.9	59 2	10.4	A0 τ			Nd	188	8.4	53 47	9.7	A0 σ		759	
145	51.4	61 16	10.2	A3 κ		331	Nb	189	8.5	54 49	10.1	A0 σ +		1259	
146	51.7	55 22	10.6	A0 σ			Nd	190	8.6	53 24	10.5	A0 σ —		1096	
147	53.0	55 8	10.4	A0 μ			Nd	191	8.8	53 23	10.5	A0 σ		1096	
148	53.3	62 5	10.1	A0 ρ			Nb	192	9.3	53 52	10.3	A0 μ		724	Sb
149	54.1	54 43	10.3	A2 σ +			Nd	193	9.4	57 10	10.7	A0 τ			Nb
150	54.5	61 56	10.2	A0 σ +			Nb	194	9.4	52 39	10.4	τ —		2630	Sb
151	54.7	54 12	10.3	A0 σ +			Nd	195	9.6	53 31	10.4	A0 σ —		1047	
152	55.9	60 19	10.6	A0 σ			Nb	196	10.7	54 40	10.1	A0 σ		912	
153	55.9	59 5	10.3	A0 τ —			Nd	197	10.8	53 54	9.8	A0 σ		794	Sb
154	55.9	55 56	10.0	A0 σ			Nd	198	11.1	61 19	10.1	A2 κ —			Nb
155	56.0	60 8	10.4	A0 τ —			Nb	199	11.1	54 14	10.5	A2 μ		794	Sb
156	56.6	59 24	10.4	A0 τ —			Nb	200	11.2	54 23	10.5	τ —		2754	
157	57.3	53 36	10.2	A0 σ +			Nd	201	11.6	55 47	10.7	A0 ρ		912	
158	58.1	53 59	10.5	A0 σ			Nd	202	11.7	55 27	10.4	A0 σ		1047	
159	58.2	61 36	10.6	A0 σ —			Nb	203	11.8	54 59	10.2	A0 σ +		1318	
160	58.2	56 25	10.7	A0 σ —			Nb	204	12.2	55 5	10.4	A0 τ		5495	
161	59.0	53 40	10.4	A2 κ —		501	Sb	205	12.3	52 56	10.0	A0 σ +		1202	Sb
162	59.3	61 46	10.3	A0 ρ			Nb	206	12.5	60 25	10.3	A0 μ			Nb
163	59.4	60 52	10.3	A0 σ +			Nb	207	12.5	52 50	10.5	A0 σ +		1514	Sb
164	59.4	53 25	10.4	A2 κ —			Nd	208	12.9	54 8	10.4	A0 τ		5495	
165	59.6	53 32	10.5	A0 τ —				209	13.6	54 41	10.5	A0 τ —		2754	
166	21 59.7	55 48	9.9	A0 τ —			Nd	210	13.7	55 41	10.5	A2 κ		417	
167	22 0.1	61 49	10.5	A0 τ —			Nb	211	13.7	54 18	10.5	A0 σ		1096	
168	0.5	54 37	10.5	A0 σ			Nd	212	13.7	54 9	9.9	A0 σ		832	
169	0.9	53 39	10.6	A0 τ —		2884	Sb	213	13.9	55 21	10.6	A2 κ —		550	
170	1.2	56 47	10.7	A0 μ			Nb	214	14.0	54 26	10.6	A0 ρ		871	
171	1.4	54 25	10.4	B8 τ —		2630	Sb	215	14.1	55 9	10.4	A0 σ +		1445	
172	1.8	61 14	9.6	A0 σ			Nb	216	14.2	53 57	10.5	A0 τ —		2754	
173	2.4	61 13	9.9	A0 μ				217	14.7	53 38	10.6	A0 σ		1148	
174	22 ^h 2 ^m .6	61°41'	10.5	A0 σ +			Nb	218	22 ^h 15 ^m .0	55°49'	9.7	A0 τ —		1905	Sb

No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.	No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.
219	$22^h 15^m.4$	$56^\circ 26'$	10.2	τ			<i>Nb</i>	268	$22^h 25^m.2$	$56^\circ 48'$	10.6	A0 σ		1148	<i>Sb</i>
220	15.6	53 0	10.4	A0 μ		759	<i>Sb</i>	269	25.9	54 28	10.6	A0 τ —		2884	<i>Sb</i>
221	15.8	52 24	10.3	A0 σ +		1380		270	26.2	52 23	10.7	A0 ρ		912	<i>Sd</i>
222	16.2	55 14	10.5	A0 σ +		1514		271	26.5	54 32	10.4	A0 τ		5495	<i>Sb</i>
223	16.7	55 50	10.3	A0 τ		5248		272	26.8	50 11	10.2	A0 μ		692	<i>Sd</i>
224	16.7	52 34	10.5	σ +		1514		273	26.9	54 39	10.6	A0 μ		832	<i>Sb</i>
225	16.8	52 28	10.5	A0 τ —		2754		274	27.0	56 5	10.1	τ		4785	<i>Sb</i>
226	16.9	52 24	10.0	B τ —		2188		275	27.2	55 29	10.5	A0 σ		1096	<i>Sd</i>
227	17.0	55 19	9.8	A0 τ —		1995		276	27.4	55 58	10.3	A0 ρ		759	
228	17.2	55 11	10.5	A0 σ		1096		277	27.5	53 17	10.4	A0 σ —		1047	
229	17.3	52 27	10.3	A0 τ —		2512		278	28.0	56 36	9.8	B τ —		1995	
230	17.6	53 45	10.5	A0 τ —		2754		279	29.3	52 0	10.5	A2 κ —		525	
231	17.6	52 41	10.2	σ +		1318		280	29.8	49 34	10.3	A0 σ —		1000	
232	17.7	55 49	9.2	τ —		1514		281	29.9	56 1	10.3	A0 τ		5248	
233	17.7	54 11	10.4	A0 τ		5495		282	31.0	52 57	10.3	A0 σ +		1380	
234	17.9	52 26	10.6	A0 σ		1148		283	31.5	51 46	10.2	A0 σ		955	<i>Sd</i>
235	18.0	51 25	10.2	A0 τ —		2400		284	32.0	49 12	10.5	A0 τ —		2754	<i>S</i> ₁
236	18.1	55 16	10.7	A0 σ		1202		285	32.4	52 53	10.6	A0 σ +		1585	<i>Sd</i>
237	18.3	55 49	10.4	A0 σ		1047		286	35.1	55 38	10.3	A0 σ +		1380	<i>Sd</i>
238	18.5	55 31	10.3	A0 σ —		1000		287	35.1	54 35	10.1	A0 σ		912	<i>Sb</i>
239	18.7	55 32	10.4	A0 σ —		1047		288	35.2	48 56	10.6	A0 σ +		1585	<i>S</i> ₁
240	19.0	56 4	10.5	A0 σ +		1514	<i>Sb</i>	289	35.4	55 47	9.8	A0 σ —		794	<i>Sd</i>
241	19.1	56 37	10.6	A0 σ			<i>Nb</i>	290	35.4	51 20	10.4	A2 μ		759	
242	19.1	53 37	10.5	A0 τ —		2754	<i>Sb</i>	291	36.6	49 40	10.5	A0 ρ		832	
243	19.2	55 18	10.2	A0 τ		5012		292	37.2	51 34	10.5	A0 τ —		2754	
244	19.3	54 15	10.6	A0 σ		1148		293	37.6	51 45	10.2	A0 σ +		1318	
245	19.3	51 16	10.5	A0 τ		5754		294	38.0	50 38	10.5	A3 κ —		525	
246	19.4	52 55	10.6	A3 κ		398		295	42.3	51 50	10.5	A0 τ —		2754	
247	19.5	55 8	10.4	A0 τ		5495		296	42.4	52 7	10.1	A0 σ		912	<i>Sd</i>
248	19.5	53 43	10.1	A0 σ +		1259		297	43.2	50 18	10.7	A0 σ —		1202	<i>S</i> ₁
249	19.6	53 18	10.5	A0 ρ		832		298	46.5	51 34	10.5	A0 σ +		1514	<i>Sd</i>
250	19.8	55 58	10.4	A2 μ		759		299	46.7	53 29	10.5	A0 μ		794	
251	20.2	56 10	10.8	A0 σ —		1259		300	49.1	53 36	10.5	A0 σ		1096	
252	20.2	55 17	10.4	A0 σ		1047		301	50.0	51 49	10.5	A2 κ		417	<i>Sd</i>
253	20.3	54 6	10.2	A0 σ		955		302	52.1	50 34	10.4	A0 σ		1047	<i>S</i> ₁
254	20.7	53 39	10.5	A0 σ		1096		303	52.5	49 52	10.5	A0 σ +		1514	
255	20.7	52 34	10.6	A0 τ —		2884		304	53.2	51 24	10.2	A0 τ —		2400	
256	21.1	55 4	10.7	A0 μ		871		305	54.2	48 32	10.4	A0 μ		759	
257	21.5	56 6	10.4	A0 τ		5495		306	54.9	51 31	10.4	A2 τ —		2630	
258	22.0	56 12	10.4	A0 τ		5495		307	55.6	50 38	10.5	A0 ρ		832	
259	22.0	51 57	10.2	A2 κ —		457		308	56.6	52 6	10.5	A0 σ —		1096	
260	22.8	51 43	10.4	A2 μ		759		309	57.1	50 36	10.5	A0 σ —		1096	<i>S</i> ₁
261	23.8	52 30	10.5	A0 τ —		2754		310	57.3	52 19	10.4	A2 κ —		501	<i>Sd</i>
262	24.2	52 46	10.2	A0 ρ		724		311	57.4	46 13	10.7	A2 μ		871	<i>S</i> ₁
263	24.4	56 41	10.5	A0 σ —		1096		312	58.3	50 16	10.4	A0 σ		1047	
264	24.5	54 38	10.4	A0 σ		1047		313	23 3.7	50 1	10.7	A0 κ —		724	
265	24.9	52 29	10.3	A0 σ +		1380		314	5.6	48 32	10.3	A2 κ —		479	
266	24.9	51 56	10.1	A0 σ		912	<i>Sb</i>	315	12.4	48 51	10.3	A0 μ		724	
267	$22^h 24^m.9$	$51^\circ 27'$	10.2	A0 μ		692	<i>Sd</i>	316	$23^h 15^m.7$	$48^\circ 6'$	10.3	A0 σ		1000	<i>S</i> ₁

C a s s i o p e i a.

317	$1^h 22^m.9$	$60^\circ 19'$	10.7	A0 σ		1202	<i>B</i>	325	$1^h 26^m.2$	$61^\circ 54'$	10.3	A0 ρ		759	<i>D</i>
318	23.5	60 1	10.5	A0 σ +		1514	<i>B</i>	326	26.4	58 10	10.5	A0 τ —			<i>D</i>
319	23.5	55 8	10.6	A0 σ —			<i>D</i>	327	26.6	60 5	10.7	τ		6310	<i>B</i>
320	23.8	55 9	10.7	A0 τ —				328	27.1	58 53	10.6	A0 σ +			<i>D</i>
321	24.3	54 35	10.5	A0 κ —		661	<i>D</i>	329	27.3	60 20	10.7	A0 τ —		3020	<i>B</i>
322	24.7	53 32	10.5	A0 μ		794	<i>B</i>	330	28.5	59 48	10.7	τ		6310	<i>B</i>
323	25.9	57 27	10.6	A0 σ +			<i>D</i>	331	29.5	58 46	10.7	A0 μ		871	<i>D</i>
324	$1^h 26^m.1$	$58^\circ 2'$	10.7	A0 τ —			<i>D</i>	332	$1^h 30^m.0$	$56^\circ 27'$	10.7	A0 σ			<i>D</i>

No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.	No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.
333	$1^h 30^m.4$	$63^\circ 27'$	10.7	A0 σ			D	376	$1^h 43^m.8$	$55^\circ 7'$	10.3	A0 μ		724	B
334	30.7	54 29	10.7	A0 ρ			D	377	43.9	57 13	10.7	A0 σ —		1202	
335	30.8	57 30	10.5	τ —		2754	B	378	44.2	56 53	10.5	A0 μ		794	
336	31.5	53 42	10.5	A0 σ —		1096		379	44.3	56 37	10.7	A0 τ —		3020	
337	31.7	57 58	10.7	A0 σ		1202		380	44.6	56 27	10.2	A0 σ +		1318	
338	31.9	59 25	10.6	A0 σ		1148	B	381	44.7	58 35	10.7	A0 τ —		3020	B
339	32.5	61 26	10.4	A0 μ		759	D	382	45.1	63 36	10.7	A2 κ		457	D
340	32.5	56 56	10.6	A0 τ				383	45.2	57 6	10.3	A0 σ +		1380	B
341	32.6	54 57	10.6	A0 σ —			D	384	45.3	58 6	10.8	A0 σ		1260	
342	32.9	58 2	10.5	A0 σ —		1096	B	385	45.3	55 37	10.4	A0 ρ		794	
343	32.9	56 48	10.7	A0 σ —		1202		386	45.5	55 37	10.2	A2 κ —		457	
344	33.1	58 17	10.7	A0 τ		6310		387	45.7	57 3	10.8	A0 σ		1260	B
345	33.3	53 56	10.7	A0 σ +		1660	B	388	46.0	59 58	10.2	B τ —			D
346	34.9	62 3	10.7	σ +			D	389	46.0	57 7	10.6	A0 σ +		1585	B
347	35.5	56 51	10.7	A0 σ		1202	B	390	46.0	56 36	10.6	τ —		2884	
348	35.5	55 47	10.2	B8 σ			D	391	46.6	56 30	10.5	B τ		5754	B
349	36.1	63 35	10.5	B τ				392	47.1	61 32	10.6	τ —			D
350	36.9	62 8	10.8	A0 σ				393	47.3	54 9	10.4	A0 σ +		1445	B
351	37.0	64 52	10.6	A0 μ		832		394	47.7	56 51	10.6	A0 ρ		871	
352	37.2	61 50	10.6	τ —				395	48.0	55 20	10.2	A0 σ —		955	
353	37.3	62 17	10.7	A0 σ +			D	396	49.3	55 17	10.6	A0 σ —		1148	B
354	37.3	59 42	10.5	A0 σ		1096	B	397	50.3	62 54	10.3	A0 τ —			D
355	37.5	60 16	10.7	A0 τ —		3020	B	398	50.5	57 3	10.7	A0 σ —		1202	B
356	37.6	62 40	10.7	A0 τ			D	399	50.9	59 29	10.0	B τ			D
357	37.6	54 4	10.4	A0 σ		1047	B	400	51.0	64 14	10.6	A3 κ		398	D
358	37.7	60 26	10.7	A0 ρ		912		401	51.2	58 59	10.7	B σ +		1660	B
359	38.1	61 52	10.7	τ —			D	402	51.3	62 33	10.7	A0 μ			D
360	38.2	61 46	10.7	A0 ρ			D	403	52.0	59 16	10.7	τ —		3020	B
361	38.2	55 37	10.7	A0 τ —		3020	B	404	52.4	53 44	10.3	A0 σ +		1380	
362	38.3	56 42	10.7	τ —		3020	B	405	53.8	58 54	10.5	A0 σ		1096	B
363	38.7	63 38	9.5	A0 ρ		525	D	406	54.0	63 25	10.7	A0 τ —			D
364	39.2	60 57	10.6	A0 σ +		1585	B	407	54.2	61 44	10.6	A0 μ		832	D
365	39.4	57 13	10.4	A0 σ +		1445		408	54.2	57 44	10.5	A0 σ		1096	B
366	40.1	54 30	10.7	A0 σ		1202		409	55.9	58 57	10.5	A0 σ —		1096	
367	40.2	57 36	10.7	A0 μ		871		410	56.6	59 39	10.6	A0 ρ		871	
368	40.2	57 36	10.5	A0 σ		1096		411	57.1	56 16	10.6	A0 ρ		871	
369	40.6	59 31	10.7	A0 μ		871		412	57.8	57 47	10.7	A0 σ		1202	
370	40.8	53 56	10.2	A0 τ —		2400		413	58.6	58 50	10.7	A0 μ		871	B
371	41.9	54 49	10.2	A0 σ +		1318		414	1 58.9	62 21	10.3	A0 σ +			D
372	42.5	55 26	10.6	A0 σ		1148		415	2 3.0	59 4	10.3	A0 σ		1000	B
373	43.1	58 3	10.6	A0 σ		1148		416	5.2	61 54	10.6	A0 σ +			D
374	43.4	56 57	10.7	A0 τ —		3020		417	$2^h 6^m.4$	$60^\circ 24'$	10.3	A0 ρ		759	D
375	$1^h 43^m.6$	$53^\circ 24'$	10.6	A0 τ —		2884	B								

A u r i g a.

418	$4^h 45^m.5$	$36^\circ 30'$	10.7	A0 σ			S	432	$4^h 57^m.5$	$41^\circ 39'$	10.2	A0 ρ		724	B
419	45.9	35 22	10.5	A0 κ —			S	433	58.2	40 32	10.6	A0 σ		1148	
420	47.1	39 24	10.2	A0 σ —		955	N	434	58.4	41 36	10.3	A2 κ —		479	
421	47.6	39 38	10.4	A0 ρ		794		435	58.7	41 7	9.7	A3 κ		263	
422	50.3	39 59	10.6	A0 σ +		1585		436	58.7	39 59	10.5	τ —		2754	
423	51.5	40 39	10.3	A0 σ +		1380	N	437	4 59.4	41 16	10.3	A2 σ		1000	
424	53.7	41 12	10.5	A0 σ		1096	B	438	5 0.0	40 42	10.6	A0 μ		832	
425	53.7	41 9	10.6	A2 κ —		550		439	0.1	41 20	10.5	A0 σ —		1096	
426	54.0	41 13	10.5	A2 κ		417		440	0.9	39 38	10.5	A0 μ		794	
427	54.2	41 6	10.5	A0 σ		1096		441	1.2	39 54	10.4	A0 ρ		794	
428	56.5	39 37	10.6	A0 σ +		1585		442	1.3	41 17	10.3	τ —		2512	
429	56.8	41 16	10.3	A0 ρ		759		443	2.1	38 42	10.6	A0 σ +		1585	
430	57.1	41 19	10.6	A0 μ		832		444	2.7	41 51	10.4	A0 μ		759	B
431	$4^h 57^m.2$	$41^\circ 29'$	10.4	A0 σ +		1445	B	445	$5^h 3^m.1$	$42^\circ 56'$	10.5	A0 μ		794	N

No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.	No.	$\alpha_{(1900)}$	$\delta_{(1900)}$	m_{ph}	Sp. U.	Sp. H.	r	Ar.
446	$5^h 4^m.1$	$41^\circ 16'$	10.4	A0 σ +		1445	B	488	$5^h 12^m.9$	$37^\circ 39'$	10.5	τ —		2754	B
447	5.0	41 40	10.4	A0 μ		759	B	489	13.6	41 25	10.7	A0 σ —		1202	N
448	5.1	42 20	10.2	A0 μ		692	N	490	14.5	43 18	10.7	A0 μ		871	
449	5.3	39 52	10.1	A0 μ		661	B	491	14.6	42 54	10.6	A2 κ —		550	
450	5.7	40 35	10.5	A2 μ		794		492	14.6	40 44	10.8	A0 μ		912	
451	5.7	39 24	10.4	A0 ρ		794		493	14.6	40 43	10.7	A0 μ		871	
452	5.7	37 51	10.5	A0 ρ		794		494	14.9	42 40	10.7	A0 τ —		3020	N
453	6.0	41 19	10.5	A0 σ		1096		495	14.9	39 22	9.8	A0 τ —		1995	B
454	6.4	41 25	10.4	A0 σ +		1445		496	15.1	42 28	10.4	A0 ρ		794	N
455	6.4	40 16	10.6	A0 τ —		2884		497	15.2	44 24	10.6	A0 σ		1148	
456	6.5	40 25	10.7	A0 σ +		1660	B	498	15.2	42 1	10.6	A0 κ —		692	
457	6.7	43 27	10.4	A0 μ		759	N	499	15.9	42 21	10.6	τ —		2884	
458	7.0	39 45	10.4	A0 τ —		2630	B	500	15.9	41 59	10.0	A0 μ		631	
459	7.1	43 41	10.6	A0 ρ		871	N	501	16.0	44 11	10.6	A0 σ +		1585	
460	7.1	40 2	10.9	A0 σ		1318	B	502	16.1	40 45	10.7	A0 σ +		1660	
461	7.3	40 40	10.9	A0 μ		955	B	503	16.4	41 21	10.7	A0 ρ		912	
462	7.5	41 45	10.4	A0 σ		1047	N	504	17.0	39 20	10.2	A2 κ		363	
463	7.7	42 2	10.5	A0 μ		794	N	505	17.1	40 50	10.7	A0 σ —		1202	
464	8.8	37 18	10.6	A0 σ +		1585	B	506	17.2	40 30	10.7	A2 κ —		575	
465	8.9	39 46	10.8	A0 σ +		1738	B	507	17.6	39 42	10.4	A2 κ		398	
466	9.0	41 37	10.6	A0 ρ		871	N	508	18.4	43 29	10.6	A2 κ —		550	
467	9.0	38 14	10.4	A0 σ		1047	B	509	18.7	43 58	10.3	A0 μ		724	
468	9.4	41 29	10.7	A0 μ		871	N	510	18.9	43 33	10.7	A2 κ —		575	
469	9.7	44 0	10.5	A0 σ		1096		511	19.0	42 49	10.7	A0 σ +		1660	
470	10.0	44 29	10.2	A0 μ		692	N	512	19.1	41 40	10.7	A0 σ		1202	
471	10.0	39 30	10.2	A0 ρ		724	B	513	19.4	43 37	10.4	A0 σ		1047	
472	10.3	41 59	10.7	A0 σ —		1202	N	514	19.5	44 11	10.6	A0 κ —		692	
473	10.3	40 5	10.6	A0 τ —		2884	B	515	20.2	41 12	10.6	A0 σ +		1585	
474	10.3	38 11	9.6	A0 τ —		1820		516	20.7	43 51	10.6	A0 σ —		1148	
475	10.4	40 12	10.5	A2 κ —		525		517	21.1	40 40	10.6	A2 κ —		550	
476	10.4	37 56	10.4	A0 ρ		794		518	21.7	41 47	10.6	A3 κ		398	
477	10.7	37 29	10.4	τ —		2630		519	21.8	44 12	10.5	A0 μ		794	
478	11.7	37 47	10.6	A0 σ		1148	B	520	22.5	41 17	10.5	A0 σ +		1514	
479	11.8	43 41	10.6	A0 τ		6026	N	521	23.9	42 41	10.7	A0 ρ		912	
480	11.9	37 6	10.5	A0 σ		1096	B	522	24.9	41 18	10.6	A0 μ		832	
481	12.1	43 24	10.4	A0 μ		759	N	523	26.7	42 49	10.7	A2 κ —		575	
482	12.1	41 33	10.4	A0 σ		1047		524	27.8	41 3	10.6	A0 σ +		1585	
483	12.2	42 40	10.7	A0 ρ		912		525	28.0	43 0	10.5	A0 μ		794	
484	12.3	40 56	10.5	A0 μ		794		526	28.3	42 1	10.7	A0 μ		871	
485	12.4	42 17	10.5	A0 ρ		832		527	28.8	39 52	10.3	A2 κ —		479	
486	12.6	42 1	10.4	A0 ρ		794		528	29.5	41 23	10.3	A0 τ —		2512	
487	$5^h 12^m.8$	$40^\circ 56'$	10.4	A0 σ +		1445	N	529	$5^h 30^m.9$	$41^\circ 45'$	10.3	A0 σ +		1380	N

Remarks.

PART I.

C y g n u s.

- 41° 3595 Variable = WW Cyg (= HD 227457).
 38 3954 This star is classified K2 in Harvard (= HD 228375). A faint K star is visible close by on my plate.
 37 3696 According to H.D. Ext. 37° 3696 is of type K8 (= HD 226821). The identification is, however, sure.
 37 3751 is of type K2 in Harvard (= HD 227477). A faint K star is visible close by on my plate.
 37 3754 The identification is somewhat uncertain for this star.
 37 3871 P Cyg = Nova Cyg 1 (= HD 193237).
 37 3877 is classified K2 in Harvard (= HD 228865). The identification is, however, sure.
 37 3940 has not been measured while in coincidence on the plate with 37° 3941.
 37 3945 the same. Coincidence with 37° 3944.
 37 3955 The type determined by me is sure.
 36 3907 According to the H.D. Cat. H γ is very wide for this star. (= HD 191610).
 36 4049 The Harvard spectrum is given as G5 (= HD 194303).
 35 3949 = HD 190864. It is remarked in the H.D. Cat. that the star 35° 3948 precedes and that its spectral type appears to be of class B.
 34 4056 The two stars are in near coincidence. No magnitudes could be measured. The spectra are determined from two plates in perfect accordance.
 34 4184 Variable = Y Cyg (= HD 198846).
 According to the Draper Catalogue and Ext. the following stars have narrow lines:
 40° 3902 (τ), 37° 3796 (σ +), 37° 3806 (τ -), 36° 3932 (τ), 36° 3934 (τ),
 36° 4016 (τ -), 35° 3966 (τ), 35° 4141 (τ -).
 The following stars of types B8—A3 according to the H.D. Cat. or Ext. are classified A5 or F0 by me: 41° 3564, 38° 3709, 38° 3720, 38° 3755, 38° 3850, 38° 3972, 36° 3965, 34° 3908, 34° 3997, 33° 3824, 33° 3851, 30° 4199.

C e p h e u s.

- 61° 2246 The Harvard spectrum is intermediate between Oe5 and B0 according to a remark in the H.D. Cat. (= HD 209975).
 59 2461 Remark in H.D. Cat. (HD 209810): Probably of class A0.
 59 2466 Remark in H.D. Cat. (HD 210219): Perhaps of class B8.
 57 2374 Remark in H.D. Cat. (HD 206773): The lines H β and H γ are bright. The dark lines are barely seen.
 51° 3420 Variable = RZ Lac (= HD 214197).
 49 3895 Remark in H.D. Cat. (HD 213991): Perhaps of class B8.
 49 4015, 16. The Harvard spectrum refers to the star 49° 4015.

49° 4045 The lines are very narrow, and the intensities resemble those in the spectrum of α Cyg; remark in the H.D. Cat. (HD 218393). α Cyg is a τ star.

According to the Draper Catalogue the following stars have narrow line: 61° 2169 (τ), 60° 2288 (τ), 56° 2794 (τ), 55° 2644 (τ), 49° 3965 (τ —).

The following stars of types A0—A3 according to the H.D. Cat. or Ext. are classified A5 or F0 by me: 60° 2323, 57° 2478, 55° 2657, 53° 2942, 53° 2998, 52° 3245, 52° 3295, 52° 3319, 51° 3311, 50° 3798, 50° 3916, 50° 3933, 48° 3995.

Cassiopeia.

61° 301 This star is classified τ from two plates independently.

60 329 The identification is uncertain.

59 378 and 59° 377 in near coincidence.

53 392 classified only on one plate.

According to the Draper Catalogue the following stars have narrow lines: 63° 274 (τ), 59° 263 (τ —), 57° 494 (τ), 56° 424 (τ —).

The following stars of types A0—A2 according to the H.D. Cat. or Ext. are classified A5 or F0 by me: 63° 206, 58° 319, 54° 397.

Auriga.

41° 1101 Variable = SX Aur (= HD 33357).

39 1192 Variable = TT Aur (= HD 33088).

38 997 The same spectral type, B τ —, is found, independently, from two plates.

36 954 Remark in the H.D. Cat.: The lines are very broad (= HD 30896).

The following stars of types A0—A3 according to the Draper Catalogue are classified A5 or F0 by me: 42° 1273, 42° 1274, 42° 1300, 42° 1355.

PART II.

6. The identification of 6 with HD 225950 is somewhat uncertain.

52. HD 227821 at $20^h 4^m.1 + 35^\circ 28'$, sp. B5.

67. The lines are narrow, according to HD Ext. (= HD 228360).

69. According to the Draper Cat. this star is designated $35^\circ 4031$ a.

Table of Contents.

	Page
<i>Preface</i>	3
<i>Chapter I.</i> Short survey of the problem of determining the space distribution of the stars. Outline of the present investigation	4
<i>Chapter II.</i> The material. Spectral classification of the stars	11
<i>Chapter III.</i> The photographic magnitudes	17
A. The apparent magnitudes	17
B. The absolute magnitudes	23
<i>Chapter IV.</i> The derivation of the star-densities	24
<i>Chapter V.</i> Dark nebulae and their influence upon the observed distribution of the stars	30
<i>Chapter VI.</i> Investigation of the different galactic regions	39
A. The region in Cygnus	39
B. The region in Cepheus	52
C. The region in Cassiopeia	66
D. The region in Auriga	71
<i>Chapter VII.</i> Comparison and discussion of results from all the regions . . .	79
1. Surface density and intensity of galactic light	79
2. The space density in the different regions	81
3. Equi-density lines	84
4. Comparison with regions at high galactic latitudes	86
5. On the luminosity curve of the A stars	89
<i>Summary.</i>	93
<i>The General Catalogue</i>	95
Part I	97
Part II	119
Remarks	124

Tryckt den 12 november 1928.

Uppsala 1928. Almqvist & Wiksells Boktryckeri-A.-B.

